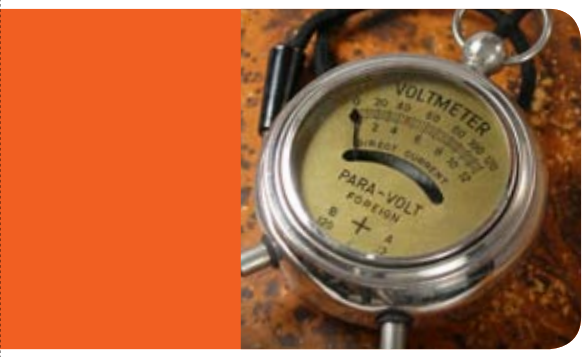
Laser Power & Energy Measurement

Laser Beam Analysis

2013



OPHIR® Photonics
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Spiricon® OPHIR Photonics
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Ophir®, now part of the Newport® Corporation Family of Brands

Ophir Photonics Group
For Every Laser Measurement

United to Lead the Industry

For over 35 years Ophir has met the challenge to consistently provide accurate and reliable laser power and energy measurement devices. Spiricon and Photon, during that time, have established themselves as the leader in beam profiling. Our first-class teams of scientists and engineers set the standard for innovation in the face of increasing demands for durability and precision.
The Ophir Photonics group leads the industry in all aspects of laser beam measurement.

Continual Improvement

Improvements in material science continually extend the operational limits of our increasingly damage resistant laser measurement devices. This not only ensures our undisputed position at the forefront of laser measurement technology, but also confirms our commitment to you in providing the most accurate and durable products in the market.
Constant attention to improved calibration methods further solidifies our leadership position in reliable and accurate instrumentation. As an ISO 9001:2008 company, we subject our products and systems to constant quality assurance monitoring. We are also proud to hold a number of patents for our creative products that clearly demonstrate our superior expertise in physics, electronics, optics, software and mechanics.

Total Commitment

Ophir - Spiricon - Photon products play an essential role in a variety of fields - medical, military industrial and research - where accuracy, reliability and robustness are vital prerequisites. We affirm our unswerving commitment to remain world leaders in the research and development of laser technology instrumentation, continually striving for improvement and innovation.

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About Ophir Optronics

Ophir Optronics, a Newport corporation brand was founded in 1976, as an optical coating company that has grown and diversified into other areas. Ophir employs a highly-qualified staff of over 570 engineers, technicians and skilled workers. Our company products are sold worldwide through a distribution network that includes four fully certified calibration facilities and repair centers. The majority of Ophir's laser measuring instrumentation line is exported and marketed by sales representatives in more than 35 countries around the world, the largest markets being the USA, Europe and Japan.

About Newport

Newport® was established 45 years ago to create and manufacture solutions to support a newly formed laser industry and quickly became the leader in vibration control, motion control and photonic tools. Our passion is photonics, our vision is to continually advance the industry by integrating leading expertise and photonics tools to create the solutions that will enable research and manufacturing to advance and create new possibilities in the markets we serve. To empower this advancement Newport has become home to a comprehensive family of leading brands including: New Focus™ with 20 years of leadership in developing, manufacturing and delivering innovative, high-performance, quality, and easy-to-use photonics. Oriel® Instruments, for 40 years, has been a pioneer in solutions for making and measuring light. Richardson Gratings™, for over 60 years, has been the gratings leader; delivering custom gratings and the largest breadth of off-the-shelf gratings. Spectra-Physics®, established 50 years ago, was a catalyst to a new industry as the first commercial laser company and today continues to lead laser innovation. And our newest addition, Ophir® founded in 1976, is a global leader in precision IR optics, laser measurement instrumentation and 3D non-contact measurement equipment.

Our Facilities

Sited in an impressive 10,400 sq.m. (112,500 sq.ft.) building in Jerusalem, Israel, Ophir's main manufacturing and R&D facility is fully equipped for both the production and testing of laser measuring instrumentation, optical components and coatings. In addition, Ophir's modern facilities have in-house capability for diamond turning, aspheric optics and electronic equipment assembly. Our laser beam profiling activities are now centered at the Spiricon facility in Logan Utah and Photon.Inc facility in San Jose California, USA with complete design, manufacturing, testing and service facilities.

Ophir's wide-ranging activities include:

- Production of the most complete variety of laser measurement instrumentation in existence, both off-the shelf and OEM. Production of very high precision infrared and visible optical components: lenses, mirrors, metallic optics (spherical, aspherical and diffractive), windows, domes and prisms, suitable for military (FLIR) and industrial (CO_2) applications. Ophir, a qualified manufacturer for some of the world's leading suppliers of night vision equipment, is renowned for having developed some of the highest performing and most cost-effective optical systems in the world.
- Design and production of optical assemblies. Thin film optical coatings.
- Non-contact optical equipment for distance measurement and three-dimensional mapping of objects developed by Optimet, a company in which Ophir has a majority share. These devices are based on patented technology called Conoscopic Holography. Application include dentistry microelectronics, robotics, quality control and mechanical shops.

Laser Development

The history of laser development has been characterized by ever-increasing laser powers and energies and increasingly concentrated laser beams. Medical, industrial and scientific applications of these high power and energy density lasers require reliable and accurate measurement of power and energy.
Meters for relatively high powers and energies generally operate by measuring the heat deposited onto an absorbing element. The key to accurate and reliable measurement is the makeup of this absorbing surface. It must stand up to repeated use without degradation or change in calibration.
Laser sources are constantly growing in power, energy and beam concentration. Ophir has an ongoing program of development of durable absorbing surfaces that will continue to stand up to the most punishing laser sources as they grow in intensity and Ophir has some of the highest damage threshold absorbers in the industry.
Ophir - Spiricon - Photon brings the same leading edge innovation to laser beam profile measurement with its famous Pyrocam, its in house designed SP and Nanoscan cameras and BeamGage software.
Ophir's Laser Measurement Group products are used in three highly competitive and sophisticated fields: medical, industrial and research. Each of these areas is further divided into end users and OEMs.

Medical

Ophir is the largest producer of laser power and energy measurement equipment for the medical market, where Ophir's power measurement devices are incorporated into laser-based instrumentation. Our products are vital to medical laser manufacturers and to the hospitals and doctors who are end-user laser purchasers.
Medical lasers cover the entire spectrum of wavelengths from the 193 nm excimer laser to the 10.6 micron CO_2 laser where the main laser wavelengths are 193, 248, 532, 694, 755, 1064, 2100, 2940 and 10600 nm. These lasers are used for general surgery, eye surgery, gynecology, ORL, dermatology and other applications. They have

outputs which start at mW and mJ on the low end going up to tens of joules and hundreds of watts at the high end. The trend in medical lasers is to progress to more powerful systems, especially in the dermatology field, and to introduce diode lasers and intense pulsed light (IPL) sources instead of the traditional gas or solid state lasers.
Ophir has developed special equipment that can for the first time measure the output of IPL sources.
Regulating bodies such as the FDA in the USA require the manufacturers to have at least one channel of power or energy monitoring in each laser. Ophir's high-quality OEM products provide an extraordinarily efficient answer to this requirement.

Industrial

Industrial laser customers include both laser manufacturers and laser users in job shops and factories. Ophir answers the needs of this market by providing measurement systems that have a high damage threshold and the ability to measure high repetition rates with high accuracy.
There are two main types of laser for industrial and material processing applications: the CO_2 laser at 10.6 microns and the Nd YAG laser at 1.064 micron. These lasers are used for cutting, welding, trimming, marking and other functions on many types of material such as metal, wood, plastic, etc. They are characterized by their high power output, which ranges from 100W to 30kW, depending on the application. With its capabilities in power, energy and profile measurement, Ophir has developed many products for this market including an integrated Laser Beam Analyzer for industrial YAG lasers which measures beam profile, temporal profile, power and energy, all in one unit. A subset of the industrial market is the microelectronics industry, which uses excimer lasers for exposing the photoresist in the photolithography process. This process uses lasers with a short wavelength of 193 to 345 nm that operate at high repetition rate and high energy. The main factor influencing the component density possible on the microchip is the wavelength of the laser already used in the process, and therefore the trend is to progress to shorter wavelengths. Ophir has a range of unique products specified for the photolithography market, including off-the-shelf and OEM products.

RoHS

Almost all Ophir and Spiricon Laser measurement products are now RoHS compliant. The few products that are not RoHS are specified as such in the ordering information.

Ophir Power and Energy Meters – Versatility for Every Application

Ophir sensor, power meter and computer interface system means that virtually any sensor can work "plug and play" with any power meter or computer interface. Ophir has the widest range of sensors on the market with the highest performance so almost any measurement need can be accommodated. The measurement results can also be used in many ways - on the power meter screen, stored on board, sent to PC with results presented in many ways and on several platforms.

Pyroelectric Sensors
Energies pJ to Joules
Rep rates to 25kHz

Thermal Sensors
Powers mW to kW and
single shot energy

Photodiode Sensors
Powers pW to Watts

Computer Interfaces
with USB / Bluetooth

Power Meters
with USB/RS232

USB Interface
basic

Pulsar
channels 4 ,2 ,1

Vega
color

Nova II
general

Quasar
wireless

Juno
compact

Nova
compact

Laser Star
2 channel

Software Solutions
StarLab, LabVIEW, StarCom
COM Object

Calibration Capability at Ophir

Calibration is perhaps the most important of our products. In order to insure the best possible calibration of your laser measuring instrumentation, Ophir takes a number of extra steps not taken by other vendors.

As can be seen by the absorption graphs in the sensor section, laser absorbers vary with wavelength, so it is not enough to calibrate at 1 wavelength. If the variation in absorption with wavelength is small, then the sensors are calibrated at several laser wavelengths and each laser covers a range of wavelengths. If the absorption variation with wavelength is considerable, the sensor software is provided with an absorption correction curve that is activated by selecting the wavelength of use. In addition to the above, only Ophir goes one step further and checks the curve at a number of NIST and PTB traceable wavelengths and corrects it if necessary. To do this, we have a complete line of calibration lasers so that we can always calibrate at or near the customer's wavelength. These lasers include powers up to 400W and both CW and pulsed lasers. In addition, we have a number of sensors calibrated at NIST and PTB used as calibration standards. Below is a list of the calibration wavelengths used at Ophir in calibrating our standard catalog sensors.

In addition to calibration variation with wavelength, there are other possible sources of calibration error such as nonlinearity variation with position on the surface and for pyroelectric sensors, pulse frequency. All of these factors are carefully taken into consideration in calibration and accounted for. For a complete discussion and analysis of Ophir calibration accuracy and error budget, please see our website at: **www.ophiropt.com/calibration-procedure/tutorial**

Special Calibration

In addition to standard calibration wavelengths shown below customers can have their Ophir sensor calibrated at additional wavelengths for more accuracy. Please consult your Ophir agent for special requests.

Wavelengths of Calibration per Sensor Type

Pulsed/Continuous	193	248	254	355	365	436	532	577	633	694	755	808	820	905	980	1014	1064	1310	1550	1600	2100	2940	10600	Spectral curve
	P	P	C	P	C	C	P,C	C	C		P	C	C	P	C	C	P,C	C	P,C	C	P	P	C	
Photodiode sensors																								
PD300					●	●		●	●							●								●
PD300-UV			●		●	●		●	●							●								●
PD300-IR													●		●	●		●	●	●				●
PD300-3W					●	●		●	●							●								●
PD300-IRG													●		●	●		●	●	●				●
3A-IS						●			●	●						●								
Thermal sensors																								
Standard Broadband<1500W							●										●						●	
Standard Broadband>=1500W																	●						●	
LP1 type							●					●			●							●		●
Comet 10K																	●						●	
Comet 1K							●										●						●	
P type							●										●							
PF type		●					●										●						●	
PF with diffuser		●		●			●										●				●			
HE type							●										●				●	●		
HE with diffuser				●			●										●							
EX type		●					●																	
SV type	●																●						●	
Pyroelectric sensors																								
PD10-C, PD10-pJ-C	●	●				●			●				●	●										●
PD10-IR-pJ-C														●					●					
PE9-C	●			●													●		●					
PE10-C	●			●													●							
BF type	●	●		●			●										●					●		●
BF with diffuser	●	●		●			●										●				●	●		●
Metallic (standard)		●		●													●					●		●
PE50-DIF-ER-C							●										●				●	●		
PE50-DIF-C	●	●															●				●	●		
PE100BF-DIF-C							●										●		●					

Sensors

Sensors Table of Contents

Power sensors

Photodiode Power Sensors

Standard photodiode sensors - 10pW - 3W

Sensor	Features	Aperture	Spectral Range	Power Range	Page
PD300	Automatic background subtraction	10x10mm	350-1100nm	500pW-300mW	22
PD300-1W	Automatic background subtraction	10x10mm	350-1100nm	500pW-1W	22
PD300-3W	High power	10x10mm	350-1100nm	5nW-3W	22
PD300-TP	Very thin profile (4mm only)	10x10mm	350-1100nm	50pW-1W	22
PD300-UV	Wide spectral range and low noise	10x10mm	200-1100nm	20pW-300mW	23
PD300-IR	Infrared	Ø5mm	700-1800nm	5nW-300mW	23
PD300-IRG	Very low noise 300 femto watts	Ø5mm (max)	800-1700nm	10pW-150mW	23

Round photodiode sensors - 20pW - 3W

Sensor	Features	Aperture	Spectral Range	Power Range	Page
PD300R	Same as PD300, circular for easy centering	Ø10mm	350-1100nm	500pW-300mW	25
PD300R-3W	Same as PD300-3W, circular geometry	Ø10mm	350-1100nm	5nW-3W	25
PD300R-UV	Same as PD300-UV, circular geometry	Ø10mm	200-1100nm	20pW-300mW	25
PD300R-IR	Same as PD300-IR, circular geometry	Ø5mm	700-1800nm	5nW-300mW	25

Special photodiode sensors and integrating spheres - 50pW - 3W and 20mLux - 200kLux

Sensor	Features	Aperture	Spectral Range	Power Range	Page
Special photodiode sensors					
PD300-BB	Flat spectral response from 430 to 1000nm	10x10mm	430-1000nm	50pW-4mW	26
PD300-BB-50mW	For broadband light sources to 50mW	10x10mm	430-1100nm	50pW-50mW	26
PD300-CIE	Measurement in units of Lux or foot candles	2.4x2.8mm	400-700nm	20mLux-200kLux	26
BC20	Meter for scanned beams at up to 30,000 inch/s	10x10mm	633, 650, 675nm	100µW-20mW	26
Special sensors - integrating spheres					
3A-IS	Integrating sphere for divergent beams to 3W	Ø12mm	420-1100nm	1µW-3W	27
3A-IS-IRG	Integrating sphere for divergent beams to 3W for near IR	Ø12mm	800-1700nm	1µW-3W	27

Thermal Power Sensors

High sensitivity thermal sensors - 30µW - 12W

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
3A	Very low powers	Ø9.5mm	0.19-20µm	60µW-3W	20µJ-2J	28
3A-P	Low powers and energies	Ø12mm	0.15-8µm	60µW-3W	20µJ-2J	28
3A-P-THz	3A-P sensor calibrated for Terahertz wavelengths	Ø12mm	0.3-10THz	50µW-3W	20µJ-2J	28
3A-FS	Lowest powers, Fused Silica window	Ø9.5mm	0.19-20µm	30µW-3W	15µJ-2J	28
3A-P-FS-12	For divergent beams, window blocks infrared	Ø12mm	0.22 - 2.1µm	60µW - 3W	20µJ-2J	28
12A	Wide dynamic range to 12W	Ø16mm	0.19-20µm	2mW-12W	1mJ-30J	29
12A-P	Short pulse lasers to 12W	Ø16mm	0.15-8µm	2mW-12W	1mJ-30J	29

Low power thermal sensors - 20mW - 50W

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
10A	General purpose to 10W	Ø16mm	0.19-20µm	20mW-10W	6mJ-2J	30
30A-BB-18	General purpose to 30W	Ø17.5mm	0.19-20µm	20mW-30W	6mJ-30J	30
L30A-10MM	Thin Profile to 30W	Ø26mm	0.15-20µm	80mW-30W	20mJ-60J	30
50(150)A-BB-26	General purpose to 50W, 150W intermittent	Ø26mm	0.19-20µm	40mW-150W	20mJ-100J	30
10A-P	Pulsed lasers up to 10W	Ø16mm	0.15-8µm	40mW-10W	10mJ-10J	31
30A-P-17	Short pulse lasers to 30W	Ø17mm	0.15-8µm	60mW-30W	40mJ-30J	31
50A-PF-DIF-18	High energy density pulsed beams	Ø17.5mm	0.24 - 2.2µm	140mW-50W	60mJ-200J	31
15(50)A-PF-DIF-18	As above, compact for intermittent use	Ø17.5mm	0.24 - 2.2µm	140mW-50W	60mJ-200J	31
30A-N-18	High power density pulsed YAG	Ø17.5mm	0.532, 1.064µm	60mW-30W	30mJ-200J	31

Low-medium power thermal sensors - apertures 17mm to 35mm, 30mW - 150W

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
30(150)A-BB-18	CW to 30W, intermittent to 150W	Ø17.5mm	0.19-20µm	30mW-150W	20mJ-100J	32
30(150)A-LP1-18	As above, high damage threshold for long pulses and CW	Ø17.5mm	0.25-2.2µm	30mW-150W	20mJ-300J	32
L50(150)A-BB-35	CW to 50W, intermittent to 150W	Ø35mm	0.19-20µm	100mW-150W	40mJ-300J	32

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
L50(150)A-LP1-35	CW to 50W, intermittent to 150W high damage threshold for long pulses	Ø35mm	0.25-2.2µm	100mW-150W	40mJ-300J	32
L50(150)A-PF-35	CW to 50W, intermittent to 150W for short pulse lasers	Ø35mm	0.15-20µm	100mW-150W	50mJ-300J	32
30(150)A-SV-17	Very high damage threshold, 30W continuous 150W intermittent	Ø17mm	0.19-12µm	100mW-150W	50mJ-300J	33
30(150)A-HE-17	High energy and average power YAGs and harmonics 30W continuous 150W intermittent	Ø17mm	0.19-0.625µm, 1.064µm, 2.1µm, 2.94µm	50mW-150W	60mJ-200J	33
30(150)A-HE-DIF-17	For highly concentrated Q switched pulses to 30W, intermittent to 150W	Ø17mm	0.19-3µm except for 625-900nm	50mW-150W	60mJ-200J	33

Medium power thermal sensors - apertures 50 to 65mm, 100mW - 300W

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
L40(150)A	CW to 35W, intermittent to 150W, large aperture	Ø50mm	0.19-20µm	100mW-150W	100mJ-200J	34
L40(150)A-LP1	As above, high damage threshold for long pulses	Ø50mm	0.25-2.2µm, 2.94µm	100mW-150W	100mJ-300J	34
L40(150)A-EX	As above for excimer lasers	Ø50mm	0.15-0.7µm, 10.6µm	100mW-150W	100mJ-200J	34
L50(150)A	CW to 50W, intermittent to 150W	Ø50mm	0.19-20µm	100mW-150W	100mJ-300J	34
L50(300)A	CW to 50W, intermittent to 300W, very large aperture	Ø65mm	0.19-20µm	400mW-300W	200mJ-300J	35
L50(300)A-LP1	As above, high damage threshold for CW and long pulses	Ø65mm	0.25-2.2µm	400mW-300W	200mJ-300J	35
L50(300)A-PF-65	CW to 50W, intermittent to 300W, large beam short pulses	Ø65mm	0.15-20µm	400mW-300W	200mJ-300J	35
L50(300)A-IPL	For gel coupled IPL sources	Ø65mm	0.5-1.1µm	400mW-300W	120mJ-300J	35

Medium-high power fan cooled thermal sensors – 50mW – 500W

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
F100A-PF-DIF-18	High average power short pulse lasers	Ø17.5mm	0.24-2.2µm	50mW-100W	60mJ-200J	36
F100A-PF-DIF-33	As above aperture 33mm	Ø33mm	0.24-2.2µm	50mW-100W	60mJ-200J	36
F150A-BB-26	Fan cooled to 150W	Ø26mm	0.19-20µm	50mW-150W	20mJ-100J	36
FL250A-BB-35	Fan cooled to 250W	Ø35mm	0.19-20µm	150mW-250W	50mJ-300J	36
FL250A-LP1-35	As above, high damage threshold for long pulses and CW	Ø35mm	0.25-2.2µm	150mW-250W	50mJ-300J	36
FL250A-LP1-DIF-33	Fan cooled to 250W with diffuser for high power and energy density	Ø33mm	0.4-3µm	400mW-250W	400mJ-600J	36
FL250A-BB-50	Fan cooled to 250W, large aperture	Ø50mm	0.19-20µm	150mW-250W	80mJ-300J	37
FL400A-BB-50	Fan cooled to 400W	Ø50mm	0.19-20µm	300mW-400W	75mJ-600J	37
FL400A-LP-50	Fan cooled to 400W, high power densities and long pulses	Ø50mm	0.4-1.5µm, 10.6µm	300mW-400W	75mJ -600J	37
FL500A	Fan cooled to 500W, very large aperture	Ø65mm	0.19-20µm	500mW-500W	100mJ-600J	37
FL500A-LP1	Fan cooled to 500W, high power densities and long pulses	Ø65mm	0.25-2.2µm	500mW-500W	100mJ-600J	37

High power water cooled thermal sensors and power pucks - 1W – 10kW

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
L250W	Thin profile, 20mm thick, water cooled to 250W	Ø50mm	0.19-20µm	1W-250W	120mJ-200J	38
L300W-LP	Thin profile, 20mm thick, water cooled to 300W	Ø50mm	0.4-1.5µm, 10.6µm	4W-300W	200mJ-300J	38
1000W	Water cooled to 1000W	Ø34mm	0.19-20µm	5W-1000W	300mJ-300J	39
1000W-LP	Water cooled to 1000W, high power densities and long pulses	Ø34mm	0.4-1.5µm, 10.6µm	5W-1000W	300mJ-300J	39
L1500W	Water cooled to 1500W	Ø50mm	0.19-20µm	15W-1500W	500mJ-200J	39
L1500W-LP	As above, high power densities and long pulses	Ø50mm	0.4-1.5µm, 10.6µm	15W-1500W	500mJ-200J	39
5000W	Water cooled to 5000W	Ø50mm	0.19-20µm	20W-5000W	N.A.	40
5000W-LP	As above, high power densities and long pulses	Ø50mm	0.4-1.5µm, 10.6µm	20W-5000W	N.A.	40
10K-W	Water cooled to 10,000W, highest power densities	Ø45mm	0.8-2µm, 10.6µm	100W-10,000W	N.A.	40
Comet 1K	Portable low-cost power probe for low powers	Ø50mm	0.2-20µm	20W-1000W	N.A.	41
Comet 10K	Portable low-cost power probe for high powers	Ø100mm	1.06µm and 10.6µm	200W-10,000W	N.A.	41
Comet 10K-HD	Portable low-cost power probe with high damage threshold	Ø55mm	1.06µm and 10.6µm	200W-10,000W	N.A.	41

StarLink Direct to PC Power Sensors

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
PD300-StarLink	Photodiode general purpose to 300mW	10x10mm	350-1100nm	500pW-300mW	N.A.	42
3A-StarLink	Very low powers to 3W	Ø9.5mm	0.19-20µm	60µW-3W	20µJ-2J	42
3A-QUAD-StarLink	Power & position, very low powers to 3W	Ø9.5mm	0.19-20µm	100µW-3W	20µJ-2J	42
3A-P-StarLink	Low powers and energies	Ø12mm	0.15-8µm	60µW-3W	20µJ-2J	42
3A-FS-StarLink	Lowest powers to 3W, Fused Silica window	Ø9.5mm	0.19-20µm	30µW-3W	15µJ-2J	42
10A-StarLink	General purpose to 10W	Ø16mm	0.19-20µm	20mW-10W	6mJ-2J	42
10A-PPS-StarLink	Power, position & size to 10W	Ø16mm	0.19-20µm	20mW-10W	6mJ-2J	42
30A-BB-18-StarLink	General purpose to 30W	Ø17.5mm	0.19-20µm	20mW-30W	6mJ-30J	42
50(150)A-BB-26-PPS-StarLink	Power, position & size to 50W, 150W intermittent	Ø26mm	0.19-20µm	40mW-150W	20mJ-100J	42
30(150)A-BB-18-StarLink	CW to 30W, intermittent to 150W	Ø17.5mm	0.19-20µm	30mW-150W	20mJ-100J	42
L50(150)A-StarLink	CW to 50W, intermittent to 150W, large aperture	Ø50mm	0.19-20µm	100mW-150W	100mJ-300J	42
FL250A-BB-50-PPS-StarLink	Power, position & size to 250W, large aperture	Ø50mm	0.19-20µm	150mW-250W	80mJ-300J	42
1000W-StarLink	Water cooled to 1000W	Ø34mm	0.19-20µm	5W-1000W	300mJ-300J	42

Power Sensor Accessories

Accessories for PD300 sensors

Fiberoptic adapters

Accessory	Description	Page
PD300 F.O. adapters	Adapters for mounting fibers to PD300 sensors (ST, FC, SMA, SC)	43

Accessories

Accessory	Description	Page
PD300-CDRH	φ7mm aperture adapter for CDRH measurements	43

Accessories for thermal sensors

Fiberoptic adapters

Accessory	Description	Page
Thermal F.O. adapters	Adapters for mounting fibers to thermal sensors (ST, FC, SMA, SC)	44

Accessories for PD300R, PD300-IRG, 3A-IS and FPS-1

Fiberoptic adapters

Accessory	Description	Page
F.O. Adapters	Adapters for mounting fibers to PD300R, PD300-IRG, 3A-IS and FPS-1 spectrum analyzer (ST, FC, SMA, SC)	44

General Accessories

Accessories

Accessory	Description	Page
SH to BNC Adapter	Allows connection of sensor to voltage measuring device for measurement of raw voltage output.	44
IR Phosphor Card	Glass slide (75x25mm) with phosphor coating (25x50mm) that visualizes spectral region 810-860nm, 900-1100nm and 1500-1600nm. Stands up to 1kW/cm^2 and 0.5J/cm^2. Self actuating, does not need charging from light source.	44

High power water cooled and fan cooled laser beam dumps

Accessories

Accessory	Description	Page
BDFL500A-BB-50	Fan cooled to 500W, general purpose high power beam dump	45
BD5000W-BB-50	Water cooled to 5000W, general purpose high power beam dump	45
BD10K-W	Water cooled to 10000W, general purpose high power beam dump	45

OEM Thermal Sensors

Standard OEM thermal sensors - 20mW - 250W

Sensor	Features	Aperture	Spectral Range	Power Range [a]	Size	Page
20C-SH	Compact smart sensor	Ø12mm	0.19-20µm	20mW-20W	38x38x14mm	49
20C-A	Compact, built-in amplifier (analog)	Ø12mm	0.19-20µm	200mW-20W	38x38x34mm	49
20C-UAU	Compact, external amplifier (USB connection)	Ø12mm	0.19-20µm	20mW-20W	38x38x14mm	49
L30C-SH	Medium aperture, smart sensor	Ø26mm	0.19-20µm	80mW-50W	60x60x38mm	50
L30C-UA	Medium aperture, built-in amplifier (RS232 connection)	Ø26mm	0.19-20µm	80mW-50W	60x60x38mm	50
L30C-UAU	Medium aperture, built-in amplifier (USB connection)	Ø26mm	0.19-20µm	80mW-50W	60x60x38mm	50
100C-SH	Low profile, smart sensor	Ø18mm	0.19-20µm	60mW-100W	48x48x14.5mm	51
100C-UA	Low profile, separate amplifier (RS232 connection)	Ø18mm	0.19-20µm	60mW-100W	48x48x14.5mm	51
100C-UAU	Low profile, separate amplifier (USB connection)	Ø18mm	0.19-20µm	60mW-100W	48x48x14.5mm	51
150C-SH	High power, smart sensor	Ø18mm	0.19-20µm	60mW-60W	50.8x50.8x33mm	52
150C-UA	High power, built-in amplifier (RS232 connection)	Ø18mm	0.19-20µm	60mW-60W	50x50x38mm	52
150C-UAU	High power, built-in amplifier (USB connection)	Ø18mm	0.19-20µm	60mW-60W	50x50x38mm	52
150W-UA	High power, built-in amplifier, water cooled (RS232 connection)	Ø18mm	0.19-20µm	100mW-150W	50x50x38mm	52
150W-UAU	High power, built-in amplifier, water cooled (USB connection)	Ø18mm	0.19-20µm	100mW-150W	50x50x38mm	52
L150C-UA	Large aperture, built-in amplifier (RS232 connection)	Ø50mm	0.19-20µm	0.2W-150W	80x80x45mm	53
L150C-UAU	Large aperture, built-in amplifier (USB connection)	Ø50mm	0.19-20µm	0.2W-150W	80x80x45mm	53
L250W-UA	Large aperture, built-in amplifier, water cooled (RS232 connection)	Ø50mm	0.19-20µm	0.3W-250W	80x80x58mm	53
L250W-UAU	Large aperture, built-in amplifier, water cooled (USB connection)	Ø50mm	0.19-20µm	0.3W-250W	80x80x58mm	53

Standard OEM thermal sensors - 0.5W - 300W

Sensor	Features	Aperture	Spectral Range	Power Range [a]	Size	Page
L300W-UA	Large aperture, built-in amplifier, water cooled (RS232 connection)	Ø50mm	0.19-20µm	0.5W-300W	80x80x58mm	53
L300W-UAU	Large aperture, built-in amplifier, water cooled (USB connection)	Ø50mm	0.19-20µm	0.5W-300W	80x80x58mm	53
Other Sensors	Ophir offers many other OEM sensors. For your OEM solution please fill the questionnaire on our website: www.ophiropt.com/photonics or contact us: USA: sales@ophir-spiricon.com Other: ophir.sales@ophiropt.com customer.support@ophiropt.com					54

Note: (a) Effective Dynamic Range for a given sensor is ~ 30:1

BeamTrack – Power / Position / Size Sensors

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
3A-QUAD	Power & position, very low powers up to 3W	Ø9.5mm	0.19-20µm	100µW-3W	20µJ-2J	56
3A-P-QUAD	As above for short pulse lasers	Ø12mm	0.15-8µm	160µW-3W	30µJ-2J	56
10-PPS	Power, position & size to 10W	Ø16mm	0.19-20µm	20mW-10W	6µJ-2J	56
50(150)A-BB-26-PPS	Power, position & size to 50W, 150W intermittent	Ø26mm	0.19-20µm	40mW-150W	20mJ-100J	57
F150A-BB-26-PPS	Power, position & size to 150W	Ø26mm	0.19-20µm	50mW-150W	20mJ-100J	57
FL250A-BB-50-PPS	Power, position & size to 250W, large aperture	Ø50mm	0.19-20µm	150mW-250W	80mJ-300J	58

Energy sensors

Photodiode and Pyroelectric Energy Sensors

Photodiode energy sensors - 10pJ - 20µJ

Sensor	Features	Aperture	Spectral Range	Energy Range	Maximum Frequency	Page
PD10-C	Very low energies down to nJ, Silicon photodiode	Φ10mm	0.19-1.1µm	1nJ-20µJ	20,000Hz	65
PD10-pJ-C	Lowest energies down to pJ, Silicon photodiode	Φ10mm	0.2-1.1µm	10pJ-200nJ	20,000Hz	65
PD10-IR-pJ-C	Lowest energies down to pJ, Germanium photodiode	Φ5mm	0.7-1.8µm	30pJ-20nJ	10,000Hz	65

Pyroelectric energy sensors - 0.2µJ - 10J

Sensor	Features	Aperture	Spectral Range	Energy Range	Maximum Frequency	Page
PE9-C	Pyroelectric for very low energies	Φ8mm	0.15-12µm	0.2µJ-1mJ	25,0000Hz	66
PE10-C	Pyroelectric for low energies	Ø12mm	0.15-12µm	1µJ-10mJ	25,000Hz	66
PE10BF-C	As above, high damage threshold	Ø12mm	0.15-3µm, 10.6µm	7µJ-10mJ	250Hz	66
PE25-C	Medium aperture pyroelectric	Ø24mm	0.15-3µm	8µJ-10J	10,000Hz	67
PE25BF-C	As above, high damage threshold	Ø24mm	0.15-3µm, 10.6µm	60µJ-10J	250Hz	67
PE50-C	Large aperture pyroelectric	Ø46mm	0.15-3µm	10µJ-10J	10,000Hz	68
PE50BF-C	As above, high damage threshold	Ø46mm	0.15-3µm, 10.6µm	120µJ-10J	250Hz	68

High energy pyroelectric sensors - 10µJ - 40J

Sensor	Features	Aperture	Spectral Range	Energy Range	Maximum Frequency	Page
PE50-DIF-C	Pyroelectric with diffuser, high repetition rate. Complete calibration curve	Ø35mm	0.19-3µm	20µJ-10J	10,000Hz	69
PE25BF-DIF-C	Pyroelectric with diffuser for high damage threshold. Complete calibration curve	Ø20mm	0.19-2.2µm	100µJ-10J	250Hz	69
PE50BF-DIF-C	Pyroelectric with diffuser for highest damage threshold. Complete calibration curve	Ø35mm	0.19-2.2µm, 2.94µm	200µJ-10J	250Hz	70
PE50BF-DIFH-C	Similar to PE50BF-DIF-C but with higher damage threshold	Φ35mm	0.19-2.2µm, 2.94µm	200µJ-10J	250Hz	70
PE50BB-DIF-C	Pyroelectric with removable diffuser. Wide spectral range w/o diffuser	Φ46mm Φ33mm with diffuser	0.19-20µm, 0.4-2.5µm with diffuser	100µJ-40J	40Hz	70
PE50-DIF-ER-C	Pyroelectric with removable diffuser. Especially for Erbium laser	Φ46mm Φ33mm with diffuser	0.19-3µm, 0.4-3µm with diffuser	10µJ-30J	10,000Hz	72
PE100BF-DIF-C	Largest aperture pyroelectric with removable diffuser	Φ96mm Φ85mm with diffuser	0.15-3µm, 0.4-2.5µm with diffuser	400µJ-40J	200Hz	72

RP sensors - 200mW - 1500W

Sensor	Features	Aperture	Spectral Range	Power Range	Maximum Frequency	Page
FL250A-RP	Long pulse lasers to 250W	Ø50mm	0.19-6µm	200mW-250W	15,000Hz	73
L1500W-LP1-RP	High power pulsed lasers	Ø50mm	0.6-1.1µm	10W-1500W	15,000Hz	73

StarLink Direct to PC Energy Sensors

Sensor	Features	Aperture	Spectral Range	Energy Range	Maximum Frequency	Page
PE10-C-StarLink	Pyroelectric for low energies	Ø12mm	0.15-12µm	1µJ-10mJ	25,000Hz	75
PE25-C-StarLink	Medium aperture pyroelectric	Ø24mm	0.15-3µm	8µJ-10J	10,000Hz	75
PE25BF-C-StarLink	As above, high damage threshold	Ø24mm	0.15-3µm, 10.6µm	60µJ-10J	250Hz	75
PE50-C-StarLink	Large aperture pyroelectric	Ø46mm	0.15-3µm	10µJ-10J	10,000Hz	75
PE50BF-C-StarLink	As above, high damage threshold	Ø46mm	0.15-3µm, 10.6µm	120µJ-10J	250Hz	75
PE50-DIF-C-StarLink	Pyroelectric with diffuser, high repetition rate. Complete calibration curve	Ø35mm	0.19-3µm	20µJ-10J	10,000Hz	75
PE50BF-DIF-C-StarLink	Pyroelectric with diffuser for highest damage threshold. Complete calibration curve	Ø35mm	0.19-2.2µm, 2.94µm	200µJ-10J	250Hz	75

Energy Sensor Accessories

Accessories for pyroelectric sensors

Fiberoptic adapters

Accessory	Description	Page
Pyroelectric F.O. Adapters	Adapters for mounting fibers to pyroelectric sensors (ST, FC, SMA, SC)	76

Accessories

Accessory	Description	Page
Removable Heat Sink	Heat sink that is fastened to rear of PE-C sensors. Allows average power ~50-70% higher than without heat sink	76
Scope Adapter	Plugs in between the PE sensor and power meter. Provides BNC output to scope to see every pulse up to the maximum frequency of the sensor.	76
Beam Splitter Assembly	Beam Splitter Assembly to measure pulsed laser sources too energetic for direct measurement. Use with the Beam Splitter can be calibrated by setting the laser to a lower energy that will not damage the sensor and swiveling between position A and B and then taking the ratio of A and B	76
Shock Absorbing Mounting Post	Mounting post same size as standard but with rubber shock absorber to insulate PE sensor from vibrations	77
Nova PE-C Adapter	The adapter plugs between the Nova D15 socket and the smart plug of the PE-C sensor to allow the Nova to operate with PE-C series sensors. See PE-C spec sheet for details.	77
Damage Threshold Test Plates	Test plates with same absorber coating as the sensor. For testing that laser beam is not above damage threshold (1 such plate is included with sensor package). There are test plates of the following types: Metallic and BF.	
PE-C to PE Size Adapter	The newer PE-C series sensors have a φ62mm diameter. The older PE series sensors have a φ85mm diameter. This adapter allows using the PE-C type sensors in jigs and setups that were originally designed for PE sensors.	77
IR Phosphor Card	Glass slide (75x25mm) with phosphor coating (25x50mm) that visualizes spectral region 810-860nm, 900-1100nm and 1500-1600nm. Stands up to 1KW/cm^2 and 0.5J/cm^2. Self actuating, does not need charging from light source.	77

Fast photodetector model FPS-1

Accessory	Description	Page
FPS-1 Fast Photodetector	Connect to oscilloscope to measure temporal beam profile. 1.5ns response time.	78

OEM Energy Sensors

Standard OEM pyroelectric energy sensors - 2µJ - 10J

Sensor	Features	Aperture	Spectral Range	Energy Range	Max. Ave. Power	Max. Freq.	Size	Page
PE10-S	Slim profile, sensitive, no amplifier	Ø12mm	0.19-3µm	2µJ-20mJ	2W	400Hz	Ø50.8x14mm	81
PE10-S-Q	Very compact, no amplifier	Ø8mm	0.19-3µm	2µJ-20mJ	2W	100Hz	30x40x14mm	81
PE25-S	Slim profile, med. aperture, no amplifier	24x24mm	0.19-3µm	0.1mJ-10J	10W	40Hz	Ø50.8x14mm	82
PE25BB-S	As above, broadband coating	24x24mm	0.19-20µm	1mJ-10J	10W	20Hz	Ø50.8x14mm	82
PE25BB-S-DIF	As above, with diffuser for high damage threshold	Ø20mm	0.4-3µm	3mJ-10J	30W	20Hz	Ø50.8x18mm	82
PE25-A-DIF-XXX-YYY [(a)]	Compact, high power, built-in electronics	Ø24mm	0.4-3µm	0.1mJ-10J	50W	1000Hz	Ø50.8x28mm	82
PE50-S	Slim profile, large aperture, no amplifier	Ø46mm	0.19-3µm	1mJ-10J	20W	10Hz	Ø75x14mm	83
PE50BB-S	As above, broadband coating	Ø46mm	0.19-20µm	10mJ-10J	15W	10Hz	Ø75x14mm	83
Other Sensors	Ophir offers many other OEM sensors. For your OEM solution please fill the questionnaire on our website: www.ophiropt.com/photonics or contact us: USA: sales@ophir-spiricon.com Other: ophir.sales@ophiropt.com customer.support@ophiropt.com							84

Note: (a) XXX denotes the calibration wavelength in µm and the YYY denotes the calibrated sensitivity in V/J.

Sensor Finder Program

Finding the proper sensor(s) to meet your measurement needs has never been easier. With our sensor finder program just enter your laser parameters and the proper measuring sensors for your application will be displayed on the screen. The program calculates the power and energy density capabilities of each absorber, based on the laser wavelength, pulse length, repetition rate and other relevant parameters. It also compares all the other requirements such as maximum and minimum power, energy, beam size, etc.

In addition to finding the right sensor for your application, the Sensor Finder Program offers the following features:

- Report printing.
- How close the recommended sensors are to the specified damage threshold.

Order of Selection

The sensors are selected in terms of cost effectiveness and ease of use, i.e. photodiode sensors and thermopiles are selected first and then pyroelectric and RP sensors. If you want to measure only power, pyro and RP sensors will not be selected even if they could operate within all other given laser parameters. If you select a repetition rate consistent with single shot energy (<=0.2Hz), RP sensors will not be selected even if they could operate within all other given laser parameters.

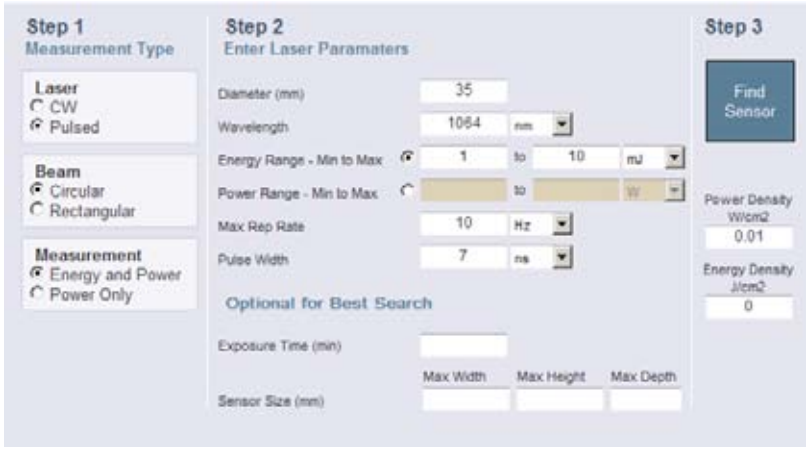
Aperture

Since it is not practical to allow the beam to fill the entire aperture, the sensors are selected so that the sensor aperture is always at least 2mm or 10% larger than the beam. If the beam is rectangular its corners can touch the aperture.

Using the Sensor Finder Program

The Sensor Finder Program is available for use online at:
www.ophiropt.com/sensor-finder
It can also be downloaded for use on your own PC at:
www.ophiropt.com/sensor-finder-download

Sensor Finder Input Screen



1. When the program is started, the above screen appears: In Step 1, Select the laser type [CW or pulsed], the beam type [circular or rectangular] and whether you wish to measure both power and energy or just laser power.

2. In Step 2, Enter the required laser parameters: beam diameter, wavelength, max/min power or max/min energy, rep rate and pulse width. If minimum power is not entered, then the program assumes the minimum is ½ the maximum.
   If desired, enter these optional criteria: exposure time – the maximum time the sensor measures at a time. If you only plan to measure the laser power for short periods at a time, Ophir offers more compact sensors for intermittent use.
   Sensor size – only sensors smaller than the specified dimensions will be selected.

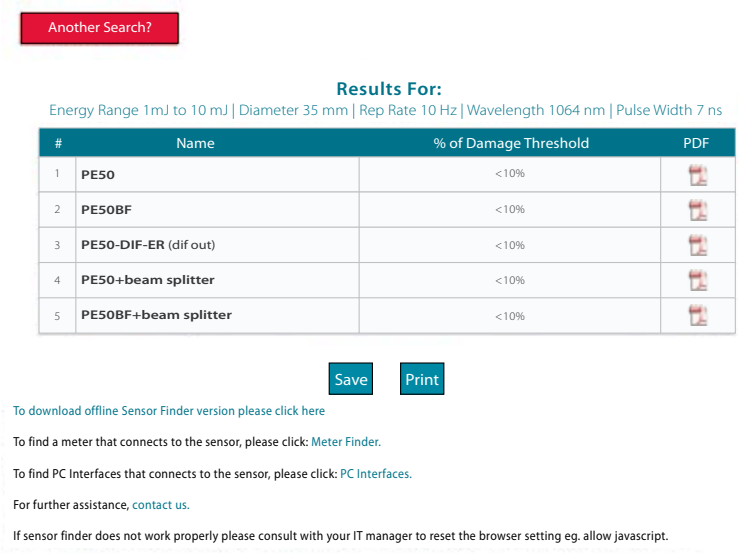
3. In Step 3 click “Find Sensor”.

4. The sensors that meet specified criteria will be listed in the output screen shown below. The sensor type and how close to the damage threshold are listed for each result. The input parameters are listed on top.

5. In order to find compatible displays, click “Meter Finder”. In order to find compatible PC interfaces click “PC Interfaces”.

6. To save the results, click “Save”. To print the results, click “Print”.

Sensor Finder Output Screen


Another Search?
Results For:
Energy Range 1mJ to 10 mJ | Diameter 35 mm | Rep Rate 10 Hz | Wavelength 1064 nm | Pulse Width 7 ns
Name % of Damage Threshold PDF
1 PE50 <10%
2 PE50BF <10%
3 PE50-DIF-ER (dif out) <10%
4 PE50+beam splitter <10%
5 PE50BF+beam splitter <10%
Save
Print
To download offline Sensor Finder version please click here
To find a meter that connects to the sensor, please click: Meter Finder.
To find PC Interfaces that connects to the sensor, please click: PC Interfaces.
For further assistance, contact us.
If sensor finder does not work properly please consult with your IT manager to reset the browser setting eg. allow javascript.

Damage Threshold

Some sensors are closer to the laser damage threshold than others. Since the damage threshold can vary somewhat from case to case and also is cumulative, the Sensor Finder Program mentions how close a particular sensor is to the damage threshold. The displayed percent of damage threshold is the highest of either the power or the energy threshold. It is recommended to select a sensor that is less than 50% of the damage threshold.

Power/Energy Meters

In order to find power/energy meters or PC interfaces that are compatible with various sensors, click "Meter Finder" or "PC Interfaces". Note that some of the newer sensors, such as the Pyro-C line sensors are only compatible with the newer meters and PC interfaces.

General Introduction

Types of Power/Energy Sensors

Power and Single Shot Energy Sensors

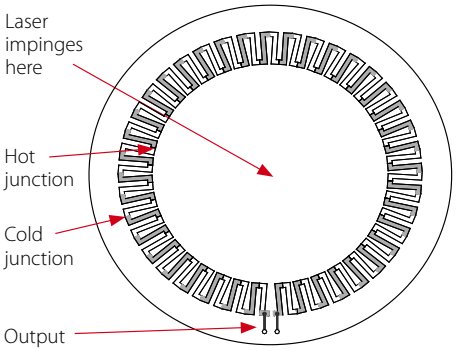
Ophir provides two types of power sensors: Photodiode sensors and Thermal sensors. Photodiode sensors are used for low powers from picowatts up to hundreds of milliwatts and as high as 3W. Thermal sensors are for use from fractions of a milliwatt up to thousands of watts. Thermal sensors can also measure single shot energy at pulse rates not exceeding one pulse every ~5s.

Repetitive Pulse Energy Sensors

For higher pulse rates, Ophir has pyroelectric energy sensors able to measure pulse rates up to tens of kHz. These are described in the energy sensor section, section 1.3.

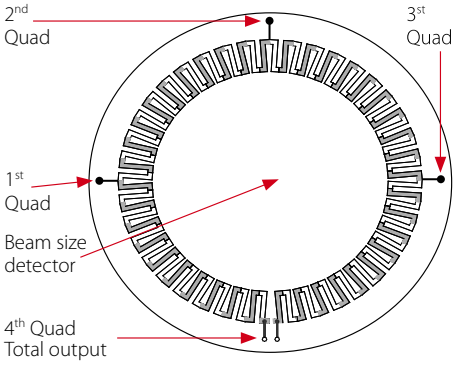
Thermal Sensors

The thermopile sensor has a series of bimetallic junctions. A temperature difference between any two junctions causes a voltage to be formed between the two junctions. Since the junctions are in series and the «hot» junctions are always on the inner, hotter side, and the «cold» junctions are on the outer, cooler side, radial heat flow on the disc causes a voltage proportional to the power input. Laser power impinges on the center of the thermopile sensor disc (on the reverse side of the thermopile), flows radically and is cooled on the periphery. The array of thermocouples measures the temperature gradient, which is proportional to the incident or absorbed power. In principle, the reading is not dependent on the ambient temperature since only the temperature difference affects the voltage generated and the voltage difference depends only on the heat flow, not on the ambient temperature. Since all the heat absorbed flows through the thermocouples (as long as the laser beam is inside the inner circle of hot junctions), the response of the detector is almost independent of beam size and position. If the beam is close to the edge of the inner circle, some thermocouples become hotter than others but since the sum of all of them is measured, the reading remains the same. Generally, Ophir specifies ±2% uniformity of reading over the surface or better.



BeamTrack Power / Position / Size sensors

Ophir now has the new BeamTrack thermal sensor that can measure beam position and beam size as well as power. This innovative device provides an additional wealth of information on your laser beam – centering, beam position and wander, beam size as well as power and single shot energy. The BeamTrack sensor is illustrated schematically here and works as follows: the signal coming from the sensor is now divided into 4 quadrants so by measuring and comparing the output from the 4 sections we can determine the position of the center of the beam to a high degree of accuracy. In addition to the 4 quadrants, there is now a special proprietary beam size detector. After processing outputs from these various detectors, the user is presented with the beam position as well as beam size. Note that the beam size is calibrated only for a Gaussian beam of >3mm but for other beams it will give relative size information and will indicate if the beam is changing size. For more information on the BeamTrack sensors, please see section 1.2.

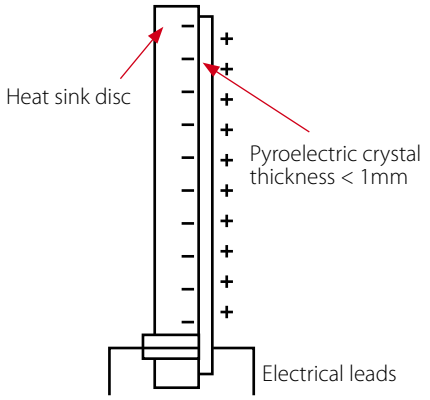


Using Power Sensors to Measure Single Shot Energy

Although Ophir thermal power sensors are used primarily to measure power, they can measure single shot energy as well where they integrate the power over time flowing through the disc and thus measure energy. Since the typical time it takes for the disc to heat up and cool down is several seconds, these thermal sensors can only measure one pulse every several seconds at most. Thus they are suitable for what is called "single shot" measurement. Although the response time of the sensor discs is slow, there is no limit to how short the pulses measured are since the measurement is of the heat flowing through the disc after the pulse.

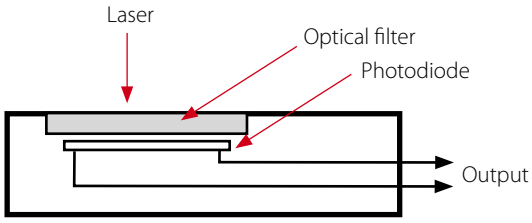
Pyroelectric Sensors

Pyroelectric type sensors are useful for measuring the energy of repetitively pulsed lasers at up to 25,000Hz and are sensitive to low energies.
They are less durable than thermal types and therefore should not be used whenever it is not necessary to measure the energy of each pulse and average power measurement is sufficient.
Pyroelectric sensors use a pyroelectric crystal that generates an electric charge proportional to the heat absorbed. Since the two surfaces of the crystal are metalized, the total charge generated is collected and therefore the response is not dependent on beam size or position. This charge then charges a capacitor in parallel with the crystal and the voltage difference thus generated is proportional to the pulse energy. After the energy is read by the electronic circuit, the charge on the crystal is discharged to be ready for the next pulse.



Photodiode Sensors for Lower Powers

In addition to the thermal sensors described above, Photodiode sensors are used for low powers from picowatts up to hundreds of milliwatts and as high as 3W.
A photodiode sensor is a semiconductor device that produces a current proportional to light intensity and has a high degree of linearity over a large range of light power levels - from fractions of a nanowatt to about 2mW. Above that light level, corresponding to a current of about 1mA, the electron density in the photodiode becomes too great and its efficiency is reduced causing saturation and a lower reading. Most Ophir PD sensors have a built-in filter that reduces the light level on the detector and allows measurement up to 3W without saturation.

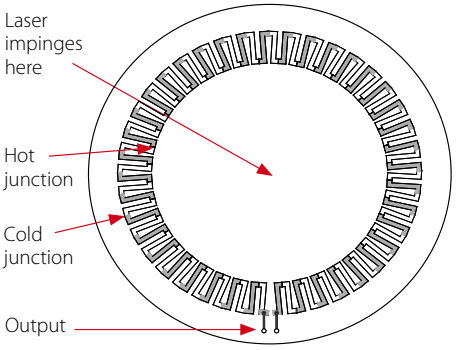


Power sensors

1.1 Power Sensors

Thermal Sensors

As described in the general introduction, the thermopile sensor has a series of bimetallic junctions. A temperature difference between any two junctions causes a voltage to be formed between the two junctions. Since the junctions are in series and the «hot» junctions are always on the inner, hotter side, and the «cold» junctions are on the outer, cooler side, radial heat flow on the disc causes a voltage proportional to the power input. Laser power impinges on the center of the thermopile sensor disc (on the reverse side of the thermopile), flows radially and is cooled on the periphery. The array of thermocouples measures the temperature gradient, which is proportional to the incident or absorbed power. In principle, the reading is not dependent on the ambient temperature since only the temperature difference affects the voltage generated and the voltage difference depends only on the heat flow, not on the ambient temperature.



Since all the heat absorbed flows through the thermocouples (as long as the laser beam is inside the inner circle of hot junctions), the response of the detector is almost independent of beam size and position. If the beam is close to the edge of the inner circle, some thermocouples become hotter than others but since the sum of all of them is measured, the reading remains the same. Generally, Ophir specifies ±2% uniformity of reading over the surface or better.

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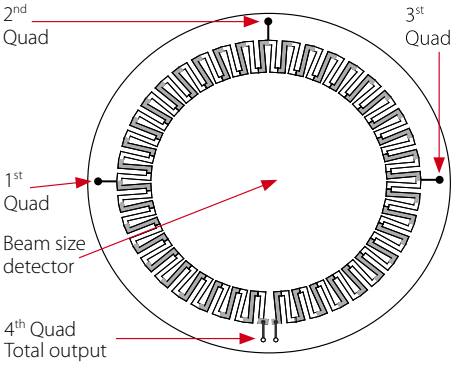


Types of Thermopile Discs

There is no single absorber which meets the needs of all applications. Ophir has developed several types for different applications, such as long pulses (0.1-10ms), short pulses (<1µs) and continuous radiation. Absorbers optimized for long pulses and CW are characterized by thin, refractory materials, since the heat can flow through the coating and into the disc during the pulse. On the other hand, heat cannot flow during short pulses, and all the energy is deposited in a thin (typically 0.1µm) layer near the surface. This causes vaporization of the surface which ruins the absorber. Instead, a volume absorber that is partially transparent and absorbs over a distance of 50µm -3mm is used. This spreads the heat over a larger volume allowing much higher energies.

Ophir thermopiles can measure from tens of microwatts to Kilowatts. Nevertheless, the thermal range of operation of the discs is limited. If the difference between the hot and cold junction temperature exceeds tens of degrees, the constant heating/cooling of the junctions can cause premature failure in the junctions. In order to accommodate different power ranges, discs of different thicknesses and sizes are used, thick ones for high powers and thin ones for low powers.

The response time of the discs is dependent on their size and shape: larger diameters and thicker discs are slower than thin small diameter ones. The response time is in general dependent on the mass of material which has to heat up in the thin absorber region of the disc vs.

the speed the heat flows out of the same region. The response time is approximately proportional to the aperture, i.e. a 50mm aperture disc is three times as slow as an 18mm aperture disc.

Thermal Surface Absorbing Heads

A surface absorber typically consists of an optically absorbing refractory material deposited on a heat conducting substrate of copper or aluminum. When a long pulse of several hundred µs or a continuous laser beam falls on such a surface absorber, the light is absorbed in a very thin layer of the surface – typically 0.1 – 1µm thickness (see illustration A). Although the light is absorbed in a thin layer and there converted into heat, the pulse is long enough so that while energy is being deposited into the surface layer, heat is also flowing out into the heat conducting substrate and therefore the surface does not heat up excessively. Ophir standard surface absorbers can stand up to 10 Joules/cm^2 for 2ms pulses and up to 28kW/cm^2 for low power continuous lasers.

Surface Absorbers for High Power Lasers and Long Pulses

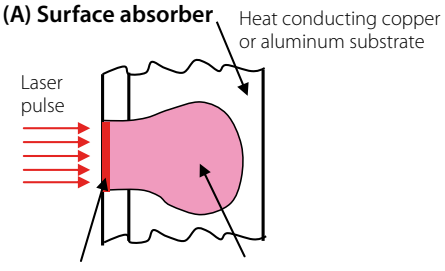
The traditional surface absorbers have a much lower damage threshold at > 1000W, where they can damage at 2-3 kW/cm^2. Ophir has developed coatings that improve the damage threshold for high power lasers. These coatings are denser and have higher heat conductivity than previous coatings. These LP and LP1 coatings also have a much higher damage threshold for long pulses reaching power damage thresholds of up to 100kW/cm^2 and 250J/cm^2 for 10ms pulses. Surface absorbers are suitable for pulses longer than ~100µs.

Surface vs. Volume Absorbers

When measuring a laser with short pulses of tens of µs or less, the heat is deposited in a short time and cannot flow during the pulse (see illustration B below). Therefore a surface absorber which absorbs the energy in a thin surface layer is not suitable. All the energy is deposited in a thin layer and that layer is vaporized. In this case, volume absorbers are used. These have traditionally consisted of a neutral density glass thermally bonded to a heat-conducting metallic substrate. The ND glass absorbs the light over a depth of 1-3 mm instead of fractions of a micrometer. Consequently, even with short pulses where there is no heat flow, the light and heat are deposited into a considerable depth of material and therefore the power/energy meter with aa volume absorber is able to withstand much higher energy densities – up to 10 Joules/cm^2 (see illustration C). These ND glasses form the basis of the Ophir P type absorbers. In addition to the P absorbers, Ophir has PF and SV absorbers that can stand up to higher average powers and power densities as well as EX absorbers for the UV.

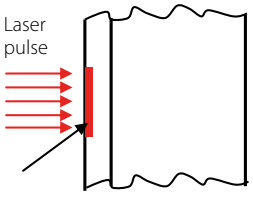
Long laser pulse (>100µs) or continuous

(A) Surface absorber


Heat conducting copper or aluminum substrate
Laser pulse
Depth of light penetration ~0.1-1µm
Heat flows into substrate during laser pulse

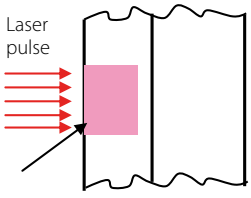
Short laser pulse <10µs

(B) Surface absorber



Depth of light penetration ~0.1-1µm. Light and heat concentrated same thin layer. Heat does not have a chance to flow during the short laser pulse duration.

(C) Volume absorber

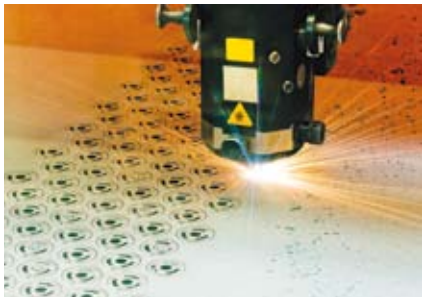


Light is absorbed gradually over thick partially transmitting layer. Heat is therefore generated over large volume even during short pulse with no heat flow.

Surface absorbers work best when measuring power or energy for long laser pulses (A). Volume absorbers can measure pulses with much higher energies than surface absorbers (B), (C) can measure.

Calibration Method and Estimated Accuracy for Ophir High Power Sensors

Ophir models 5000W, 10K-W and Comet 10K are calibrated using relatively low power lasers ~ 150 - 300W. Using such low power lasers to calibrate the instrument vs. the high power at which the sensors are used raises the question of calibration accuracy. The following explanation clearly demonstrates that the 5000W, 10K-W and Comet 10K are indeed accurate to ±5% over their measurement range. The 5000W and 10K-W sensors work on the thermopile principle, where the radial heat flow in the absorber disk causes a temperature difference between the hot and cold junctions of the thermopile which in turn causes a voltage difference across the thermopile. Since the instrument is a thermopile voltage generating device, it must be linear at low values of output. Therefore, if it is shown to be linear at powers which are a significant fraction of the maximum power, it will necessarily



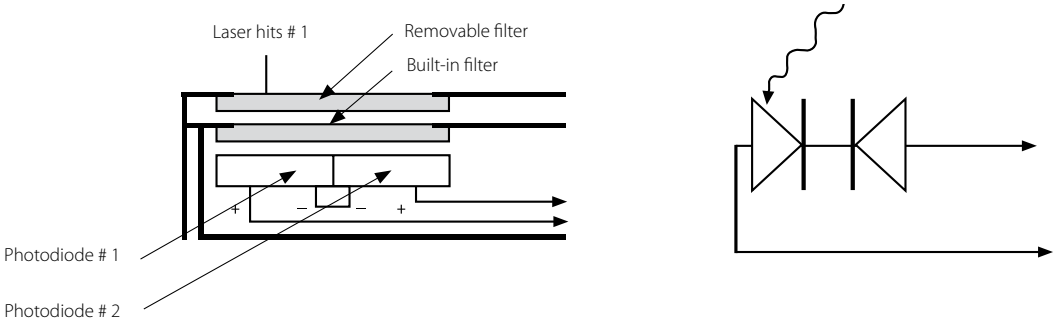
be linear at very low powers and if the calibration is correct at low powers, it will remain correct at high powers as well. On the other hand, although the output may be linear at low powers, there may be a zero offset that, due to the relatively low output at low powers, will cause an error in calibration.
For example, if calibration is performed at 200W and the output of the sensor is 10µV/W (a typical value) and there is a zero offset of only 1µV, this will cause a calibration error of 10%. Ophir's calibration method always measures the difference between the reading with power applied and without power applied, thus eliminating error due to zero offset. This measurement is taken several times to insure accuracy. The above measurement method assures that the calibration inaccuracy due to measurement errors is less than 1%, comparable to the expected errors in our lower powered sensors. In order to verify this, models L1500W, 5000W and 10K-W sensors have been measured by various standards laboratories. These measurements have shown Ophir sensors to be well within the claimed limits of linearity. The Comet 10K series measures the heat rise of the absorbing puck when irradiated by the laser for 10s. In order to calibrate the Comet 10K, we simply irradiate with a lower power laser for longer e.g. 150W for 60s. Thus the heating effect is similar to that of a higher power laser. Tests of the Comet calibrated by this method vs. NIST traceable high power sensors has shown that it is accurate and reproducible. For more information on calibration please see our website at:
www.ophiropt.com/calibration-procedure/tutorial

Photodiode Sensors

A photodiode sensor is a semiconductor device that produces a current proportional to light intensity and has a high degree of linearity over a large range of light power levels - from fractions of a nanowatt to about 2 mW. Above that light level, corresponding to a current of about 1mA, the electron density in the photodiode becomes too great and its efficiency is reduced causing saturation and a lower reading. Most Ophir PD sensors have a built-in filter that reduces the light level on the detector and allows measurement up to 30mW without saturation. Most sensors have an additional removable filter allowing measurement to 300mW or 3 Watts depending on the model.

Principle of Operation

When a photon source, such as a laser, is directed at a photodiode detector, a current proportional to the light intensity and dependent on the wavelength is created. Since many low power lasers have powers on the order of 5 to 30mW, and most photodiode detectors saturate at about 2mW, the PD300 sensor has been constructed with a built-in filter so the basic sensor can measure up to 30mW without saturation. With the removable extra filter, the PD300 sensors series can measure up to 300mW or 3W depending on the model.
The Ophir power meter unit amplifies this signal and indicates the power level received by the sensor. Due to the superior circuitry of the Ophir power meters, the noise level is very low and the PD300 series sensors with Ophir power meter have a large dynamic range from picowatts to watts. The PD300 is shown schematically below. The PD300 and PD300-3W have the exclusive patented dual detectors connected back to back which eliminate any signal illuminating both detectors equally (background light).

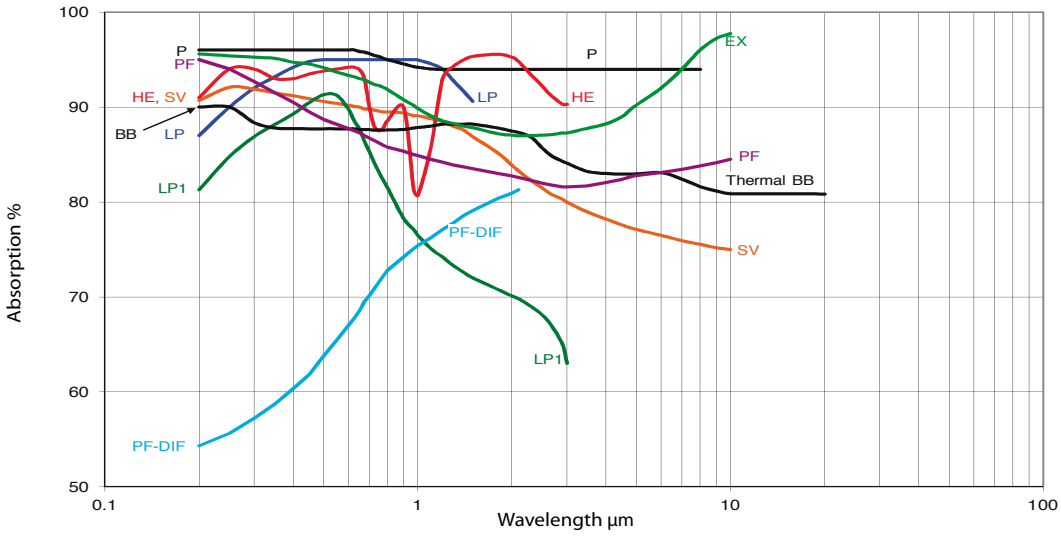


Calibration and Accuracy

The sensitivity of various photodiode sensors varies from one sensor to another as well as with wavelength. Therefore, each PD300 sensor is individually calibrated against a NIST standard, which has been calibrated at several nm intervals over the entire spectral range. The calibration is done over the entire spectral range against the NIST standard using a computer-controlled monochromator. Since the instruments are calibrated against NIST standards, the accuracy is generally ±3% over the wavelength range the calibration has been performed. The linearity of the photodiode detector is extremely high and errors due to this factor can be ignored, as long as saturation intensity is not approached. For more information on calibration accuracy please see our website at:
www.ophiropt.com/calibration-procedure/tutorial

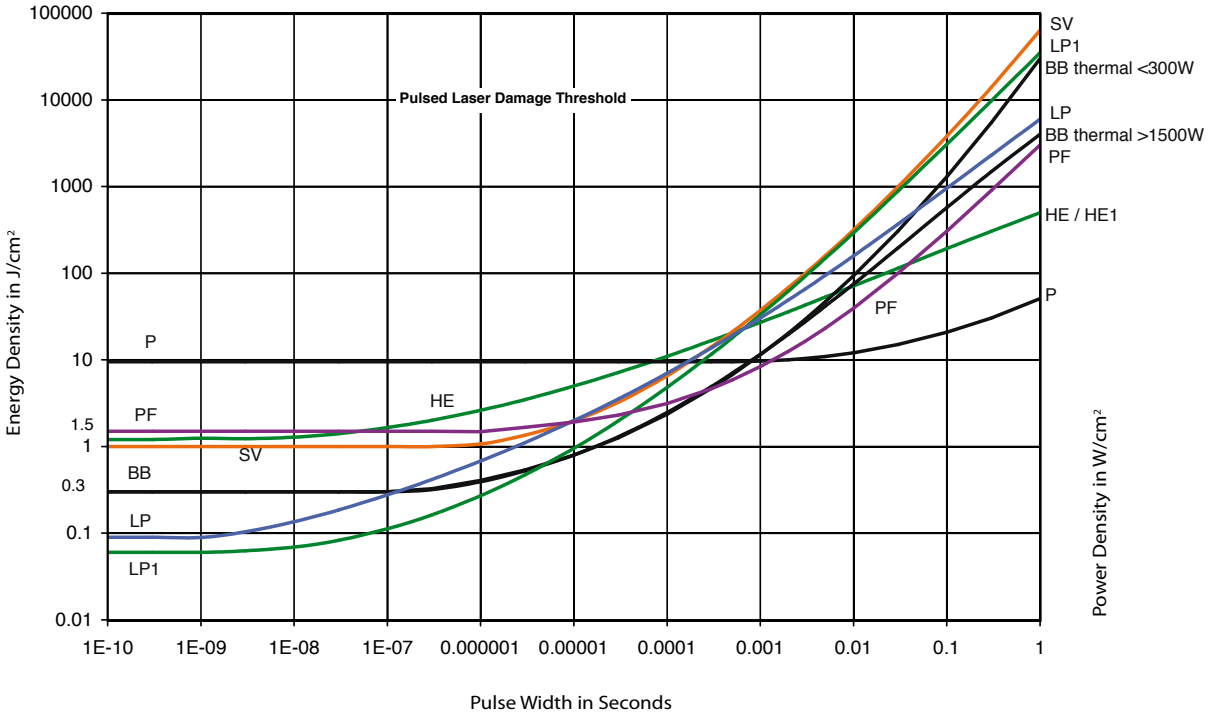
Absorption and Damage Graphs for Thermal Sensors

Absorption vs. Wavelength



Damage Threshold vs. Pulse Width

Note: The CW power damage threshold in W/cm² is found on the right hand side of the table at the 1s pulse width value.



1.1.1 Photodiode Power Sensors

1.1.1.1 Standard Photodiode Sensors

50pW to 3W

Features

- Very large dynamic range
- Swivel mount for hard to measure places
- Comes with filter in / filter out options
- Patented automatic background subtraction
- Fiber optic adapters available

PD300 with filter off

PD300 with filter installed

PD300-TP Mounted on stand

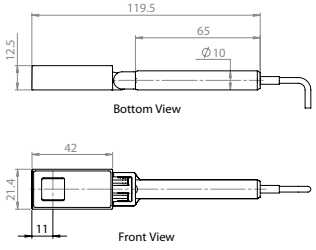
Model	PD300			PD300-1W			PD300-3W			PD300-TP		
Use	**General**			**Powers to 1W**			**Powers to 3W**			**Thin profile for tight fit**		
Detector Type	silicon			silicon			silicon			silicon		
Aperture	10x10mm			10x10mm			10x10mm			10x10mm		
Filter mode	Filter out		Filter in	Filter out		Filter in	Filter out		Filter in	Filter out		Filter in
Spectral Range nm	350-1100		430-1100	350-1100		430-1100	350-1100		430-1100	350-1100		400-1100
Power Range	30mW to 500pW		300mW to 200µW	30mW to 500pW		1W to 200 µW	100mW to 5nW		3W to 200µW	3mW to 50pW		1W to 20µW
Power Scales	30mW to 30nW and dBm		300mW to 30mW and dBm	30mW to 30nW and dBm		1W to 30mW and dBm	100mW to 300nW and dBm		3W to 30mW and dBm	3mW to 3nW and dBm		1W to 3mW and dBm
Resolution nW	0.01		NA	0.01		NA	0.1		NA	0.001		1
Maximum Power vs. Wavelength	nm	mW	mW	nm	mW	mW	nm	mW	mW	nm	mW	mW
	<488	30	300	<488	30	1000	<488	100	3000	350-400	3	NA
	633	20	300	633	20	1000	633	100	3000	400-500	3	1000
	670	13	200	670	13	1000	670	100	2000	600	2.5	1000
	790	10	100	790	10	600	790	100	1200	700	2	500
	904	10	100	904	10	700	904	100	1200	800-950	1.5	300
	1064	25	250	1064	25	1000	1064	100	2200	1064	3	500
Accuracy (including errors due to temp. variations)												
% error vs Wavelength nm	±10	360-400	NA	±10	360-400	NA	±10	360-400	NA	±7	350-400	NA
	±3	400-950	±5 430-950	±3	400-950	±5 430-950	±3	400-950	±5 430-950	±3	400-950	±5 400-950
	±5	950-1100	±7 950-1100	±5	950-1100	±7 950-1100	±5	950-1100	±7 950-1100	±5	950-1100	±7 950-1100
Damage Threshold W/cm²	10		50	10		10 [(a)]	10		100	10		50
Max Pulse Energy µJ	2		20	2		100	20		500	1		100
Noise Level for filter out pW	20			20			200			±2		
Response Time with Meter s	0.2			0.2			0.2			0.2		
Beam Position Dependence	±2%			±2%			±2%		±3%	±2%		
Background Subtraction	95-98% of background is cancelled automatically under normal room conditions, even when changing continuously						NA			NA		
Fiber Adapters Available (see page 43)	SMA, FC, ST, SC			SMA, FC, ST, SC			SMA, FC, ST, SC			NA		
Version							V1					
Part Number: Standard Sensor	**7Z02410**			**7Z02411A**			**7Z02426**			**7Z02424**		
StarLink Sensor: Direct USB link to PC (p. 42)	**787100**											

Note: (a) Maximum power density

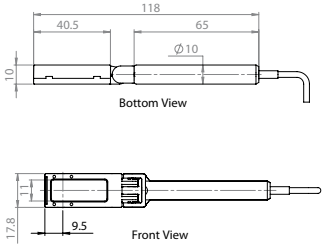
For graphs see page 24

For PD300-3W drawing see PD300-UV/PD300-IR drawing in page 23

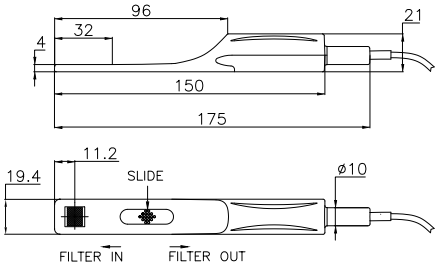
PD300/ PD300-1W filter installed



PD300/ PD300-1W filter off



PD300-TP



OPHIR Photonics A Newport Corporation Brand

1.1.1.1 Standard Photodiode Sensors

10pW to 300mW

Features

- Spectral range including UV and IR
- Very large dynamic range
- Swivel mount for hard to measure places
- Comes with filter in / filter out options
- Fiber optic adapters available

PD300 with filter off

PD300 with filter installed

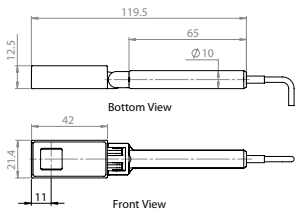
PD300-IRG with no fiber input

PD300-IRG with fiber input

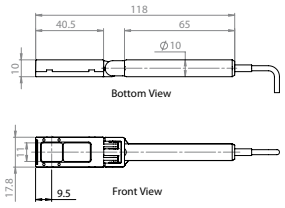
Model	**PD300-UV**				**PD300-IR**				**PD300-IRG**			
Use	**Lowest powers from 200-1100nm**				**Low powers from 700-1800nm**				**Telecom wavelength fiber and free space measurements**			
Detector Type	silicon				germanium				InGaAs			
Aperture	10x10mm				φ5mm				φ5mm for free space beams			
Filter mode	Filter out		Filter in		Filter out		Filter in		Filter out		Filter in	
Spectral Range nm	200 -1100		220 -1100		700-1800		700-1800		800 - 1700		950 - 1700	
Power Range	3mW to 20pW		300mW to 2µW		30mW to 5nW		300mW to 200µW		800µW to 10pW		150mW to 20µW	
Power Scales	3mW to 3nW and dBm		300mW to 300µW and dBm		30mW to 30nW and dBm		300mW to 30mW and dBm		800 µW to 800pW and dBm		300mW to 3mW and dBm	
Resolution nW	0.001		100		0.01		NA		0.0001		1	
Maximum Power vs. Wavelength	nm	mW	mW		nm	mW	mW		nm	mW	mW	
	250 - 350	3	300		800	12	120		<1000	0.8	100	
	400	3	300		1000-1300	30	300		1100	0.8	30	
	600	3	300		1400	30	250		1200	0.8	50	
	800 - 950	2.5	150		1500	25	80		>1300	0.8	150	
	1064	3	30		1600	30	100					
					1800	30	300					
Accuracy (including errors due to temp. variations)												
% error vs Wavelength nm	±6	200-270	±10	220-400	±5	700-900	±7	700-900	±3	1000-1650	±6	1000-1650
	±3	270-950	±5	400-950	±4	900-1700	±6	900-1700	±5	<1000 & >1650	±8	<1000 & >1650
	±5	950-1100	±7	950-1100	±7	1700-1800	±9	1700-1800				
Damage Threshold W/cm²	10		50		10		50		5		50	
Max Pulse Energy µJ	0.4		15		0.3		3		1		100	
Noise Level for filter out pW	±1				200				±300fW at 1550 nm and 1s average			
Response Time with Meter s	0.2				0.2				0.2			
Beam Position Dependence	±2%				±2%				±1% over 80% of aperture			
Fiber Adapters Available (see page 43&44)	SC, ST, FC, SMA				SC, ST, FC, SMA				FC, FC/APC, SMA			
Version									V1			
Part Number	**7Z02413**				**7Z02412**				**7Z02402**			

For graphs see page 24

PD300-UV/PD300-IR

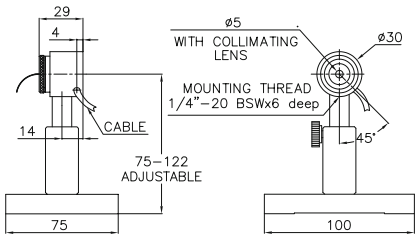


with filter installed

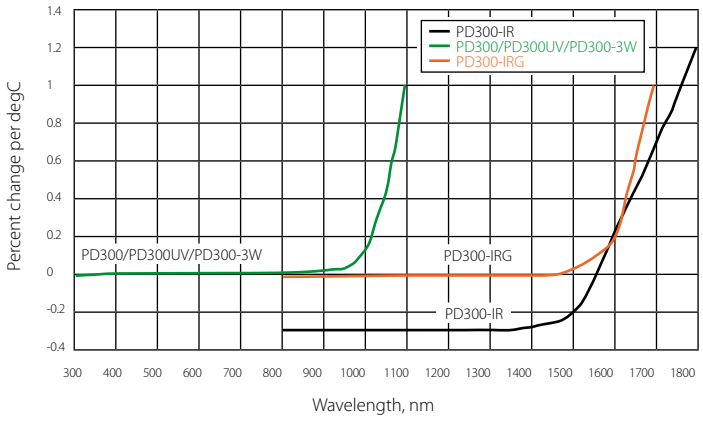


with filter off

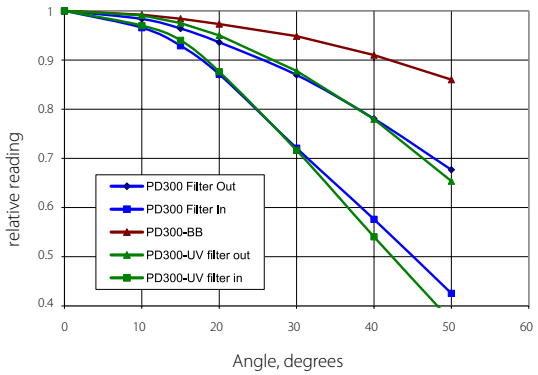
PD300-IRG



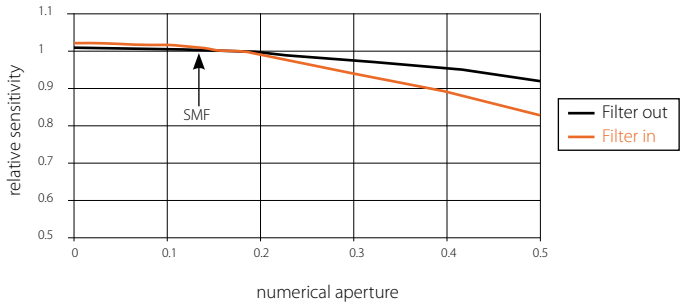
Temperature Coefficient of Sensitivity



PD300 Angle Dependence



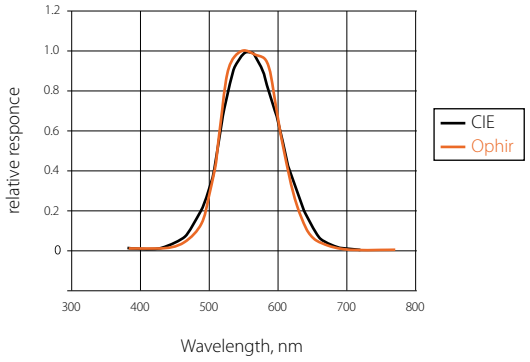
Dependence of Sensitivity on Numerical Aperture (PD300 - IRG)



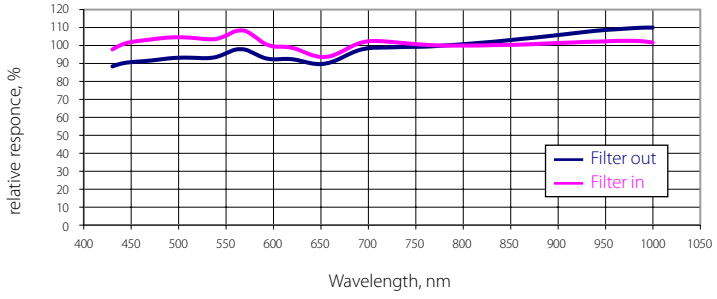
Note:

1. Graph assumes equal intensity into all angles up to maximum N.A.
2. Calibration is done with SMF, N.A. 0.13

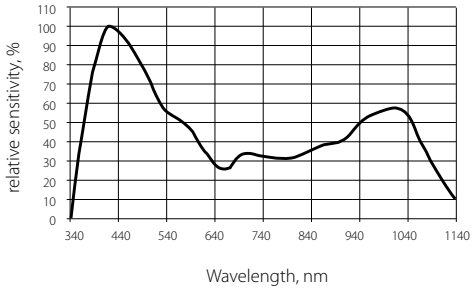
PD300-CIE spectral response vs. CIE curve



Typical Sensitivity Curve of PD300-BB Sensors



Relative Spectral Response of BC20



Graph of the approximate relative spectral response of the BC20 for purpose of interpolation, if the instrument is to be used at a wavelength other than the ones that are factory calibrated

1.1.1.2 Round Photodiode Sensors

20pW to 3W

Features

- Round geometry for easy centering
- Threaded to fit standard SM1 bench equipment
- Same performance as standard PD300 sensors
- Comes with removable filter as standard
- Fiber optic adapters available

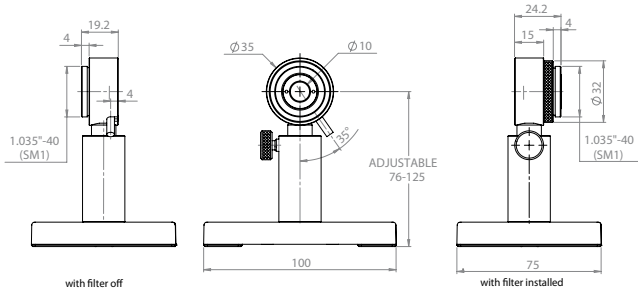
PD300R Filter Off

PD300R Filter installed

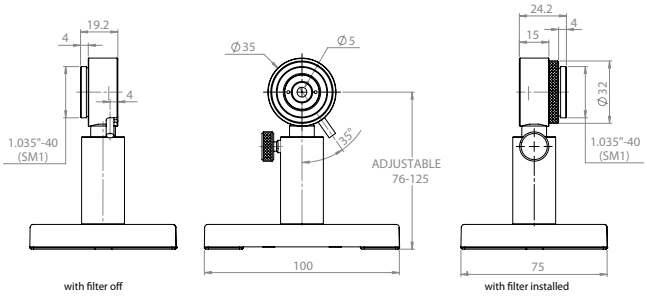
Model	PD300R			PD300R-3W			PD300R-UV			PD300R-IR		
Use	**General**			**Powers to 3W**			**Lowest powers from 200-1100nm**			**IR wavelengths 700-1800nm**		
Detector Type	silicon			silicon			silicon			germanium		
Aperture	φ10mm			φ10mm			φ10mm			φ5mm		
Filter mode	Filter out		Filter in	Filter out		Filter in	Filter out		Filter in	Filter out		Filter in
Spectral Range nm	350-1100		430-1100	350-1100		430-1100	200 -1100		220 -1100	700-1800		700-1800
Power Range	30mW to 500pW		300mW to 200µW	100mW to 5nW		3W to 200µW	3mW to 20pW		300mW to 2µW	30mW to 5nW		300mW to 200µW
Power Scales	30mW to 30nW and dBm		300mW to 30mW and dBm	100mW to 300nW and dBm		3W to 30mW and dBm	3mW to 3nW and dBm		300mW to 300µW and dBm	30mW to 30nW and dBm		300mW to 30mW and dBm
Resolution nW	0.01		NA	0.1		NA	0.001		100	0.01		NA
Maximum Power vs. Wavelength	nm	mW	mW	nm	mW	mW	nm	mW	mW	nm	mW	mW
	<488	30	300	<488	100	3000	250 - 350	3	300	800	12	120
	633	20	300	633	100	3000	400	3	300	1000-1300	30	300
	670	13	200	670	100	2000	600	3	300	1400	30	250
	790	10	100	790	100	1200	800 - 950	2.5	150	1500	25	80
	904	10	100	904	100	1200	1064	3	30	1600	30	100
	1064	25	250	1064	100	2200				1800	30	300
Accuracy (including errors due to temp. variations)												
% error vs Wavelength nm	±10	360-400	NA	±10	360-400	NA	±6	200-270	±10 220-400	±5	700-900	±7 700-900
	±3	400-950	±5 430-950	±3	400-950	±5 430-950	±3	270-950	±5 400-950	±4	900-1700	±6 900-1700
	±5	950-1100	±7 950-1100	±5	950-1100	±7 950-1100	±5	950-1100	±7 950-1100	±7	1700-1800	±9 1700-1800
Damage Threshold W/cm²	10		50	10		100	10		50	10		50
Max Pulse Energy µJ	2		20	20		500	0.4		15	0.3		3
Noise Level for filter out pW	20			200			±1			200		
Response Time with Meter s	0.2			0.2			0.2			0.2		
Beam Position Dependence	±2%			±2%		±3%	±2%			±2%		
Fiber Adapters Available (see page 44)	FC, ST, SC, SMA			FC, ST, SC, SMA			SC, ST, FC, SMA			SC, ST, FC, SMA		
Version												
Part Number	**7Z02436**			**7Z02437**			**7Z02438**			**7Z02439**		

For graphs see page 24

PD300R/ PD300R-3W/ PD300R-UV



PD300R-IR



1.1.1.3 Special photodiode sensors and integrating spheres

1.1.1.3.1 Special Photodiode Sensors

Features

- PD300-BB for broadband light sources - radiometry (PD300-BB-50mW option up to 50mW)
- PD300-CIE for eye adjusted Lux measurements
- BC20 for measuring scanned beams such as bar code light sources

BC20

PD300-BB/ / PD300-BB-50mW

PD300-CIE

Model	**PD300-BB**	**PD300-BB-50mW**		**PD300-CIE** [b]	**BC20** [b]
Use	**Radiometry-broad spectrum**	**Same as PD300-BB with removable attenuator for use to 50mW**		**Eye adjusted measurement in Lux**	**Scanned beams e.g. bar code**
Detector Type	Silicon with special filter	Silicon with special filter		Silicon with special filter	Silicon with peak and hold circuit
Aperture	10x10mm	10x10mm		Active area 2.4 x 2.8mm	10x10mm
Spectral Range nm	430 - 1000 (see graph)	430 - 1000 (see graph)		400 - 700 (see graph)	633, 650, 675 (others available)
Filter Mode		Filter out	Filter in		
Power Range	4mW to 50pW	4mW to 50pW	50mW to 1nW	200kLux to 20 mLux	20mW to 100µW
Power Scales	4mW to 8nW and dBm	4mW to 8nW and dBm	50mW to 80nW and dBm	200kLux to 200 mLux	20mW to 2mW
Resolution nW	0.001	0.001	0.01	1 mLux	0.001
Accuracy	Maximum deviation from flat spectrum (see graph) ±10%	Maximum deviation from flat spectrum (see graph) ±10%	±12%	(see graph)	±3% for >10% of full scale. Deviation from calibration -3% at 30,000 inch/s scan rate on sensor.
Damage Threshold W/cm²	10	10	100	10	50
Max Pulse Energy µJ	1	1	10	1	NA
Noise Level pW	2	2	30	±1mLux	5µW
Response Time with Meter s	0.2	0.2	0.2	0.2	Two modes of operation: Hold: holds highest reading for 5s then updates. No Hold: updates reading 3 times per second.
Beam Position Dependence	±2% for broadband light sources	±2% for broadband light sources	±3% for broadband light sources	NA – source overfills detector	±2%
Background Subtraction	NA	NA	NA	NA	Background is automatically subtracted from both scanned and static beams.
Fiber Adapters Available (see page 43)	NA	SC, ST, FC, SMA		NA	NA
Version					
Part Number	**7Z02405**	**7Z02440**		**7Z02406**	**7Z02422A**[a]

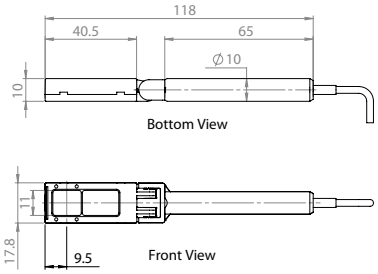
Notes:

(b) The PD300-CIE and BC20 sensors are not fully supported by Ophir PC Interfaces (Juno, USBI, Pulsar and Quasar) or by StarLite Meter.

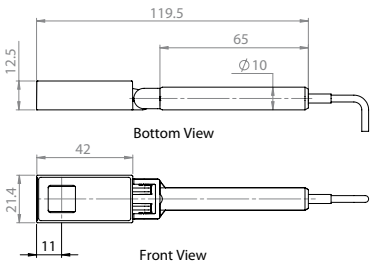
(a) Swivel stand for BC20 sensor P/N 1Z09004

For graphs see page 24

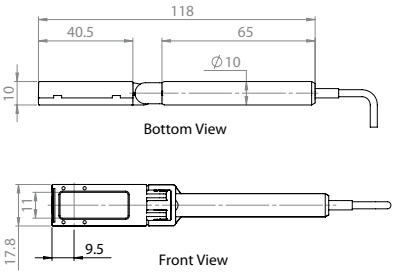
PD300-BB-CIE / PD300-BB / PD300-BB-50mW with filter off



PD300-BB-50mW with filter installed



BC20



1.1.1.3.2 Special Sensors - Integrating Spheres

1µW to 3W

Features

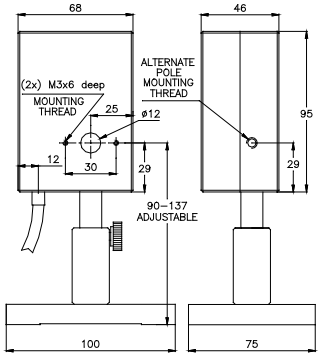
- Integrating sphere for divergent beams
- φ12mm aperture
- For fiber or free space input

3A-IS

3A-IS-IRG

Model	3A-IS	3A-IS-IRG
Use	**Divergent beams to 3W for visible NIR**	**Divergent beams to 3W for IR**
Absorber Type	Integrating sphere with Si detector	Integrating sphere with InGaAs detector
Spectral Range µm	0.42 - 1.1	0.8 - 1.7
Aperture mm	φ 12mm	φ 12mm
Maximum Beam Divergence	±40 degrees	±40 degrees
Sensitivity to beam size and angle	±2%	±2%
Power Mode		
Power Range	1µW - 3W	1µW - 3W
Power Scales	3W to 3µW and dBm	3W to 3µW and dBm
Power Noise Level	20nW	20nW
Maximum Average Power Density kW/cm²	0.2 on integrating sphere surface	
Response Time with Meter (0-95%) typ. s	0.2	0.2
Power Accuracy +/-%	5 at 420-1000nm, 10 at 1000-1100nm	5
Linearity with Power +/-%	1	1
Energy Mode		
Energy Range	NA	NA
Energy Scales	NA	NA
Minimum Energy mJ	NA	NA
Maximum Energy	5mJ	5mJ
Maximum Energy Density J/cm² (b)		
<100ns	0.5	0.5
0.5ms	6	6
2ms	12	12
10ms	25	25
Cooling	convection	convection
Fiber Adapters Available (see page 44)	SC, ST, FC, SMA (a)	SC, ST, FC, SMA (a)
Weight kg	0.6	0.6
Version	V1	
Part number	**7Z02404**	**7Z02403**
Notes:	(a) One fiber output port available with output = 2E-4 of input power/mm² of fiber area. (b) On integrating sphere surface.	

3A-IS/ 3A-IS-IRG



1.1.2 Thermal Power Sensors

1.1.2.1 High Sensitivity Thermal Sensors

30µW to 3W

Features

- Very low noise and drift to measure very low powers and energies
- Broadband and P absorbers for CW and short pulses
- Up to 3W
- Spectrally flat
- Version for Terahertz

3A / 3A-P / 3A-P-THz

3A-FS

3A-P-FS-12

Model	3A	3A-P	3A-P-THz	3A-FS	3A-P-FS-12
Use	**General purpose**	**Short pulses**	**Calibrated for Terahertz radiation**	**With removable window**	**For divergent beams, window blocks infrared**
Absorber Type	Broadband	P type	P type	Broadband + F.S. window	P type + F.S. window
Spectral Range µm	0.19 - 20	0.15 - 8	0.3 - 10THz	0.19 - 20 (b)	0.22 - 2.1
Aperture mm	φ 9.5mm	φ 12mm	φ 12mm	φ 9.5mm	φ 12mm
Maximum Beam Divergence	NA	NA	NA	NA	±40 degrees
Power Mode					
Power Range	60µW - 3W	60µW - 3W	50µW - 3W	30µW - 3W	60µW - 3W
Power Scales	3W to 300µW	3W to 300µW	3W to 300µW	3W to 300µW	3W to 300µW
Power Noise Level	2µW	4µW	4µW(d)	2µW	6µW
Thermal Drift (30min) (a)	5 - 20µW	5 - 30µW	5 - 30µW	2 - 10µW	20 - 40µW
Maximum Average Power Density kW/cm²	1	0.05	0.05	1	0.05
Response Time with Meter (0-95%) typ. s	1.8	2.5	2.5	1.8	2.5
Power Accuracy +/-%	3	3	15 (c)	3	3
Linearity with Power +/-%	1.5	1.5	1.5	1.5	1.5
Energy Mode					
Energy Range	20µJ - 2J	20µJ - 2J	20µJ - 2J	15µJ - 2J	20µJ - 2J
Energy Scales	2J to 200µJ	2J to 200µJ	2J to 200µJ	2J to 200µJ	2J to 200µJ
Minimum Energy	20µJ	20µJ	20µJ	15µJ	20µJ
Maximum Energy Density J/cm² (e)					
<100ns	0.3	1	0.1	0.3	1
0.5ms	1	1	1	1	1
2ms	2	1	1	2	1
10ms	4	1	1	4	1
Cooling	convection	convection	convection	convection	convection
Weight kg	0.2	0.2	0.2	0.2	0.15
Fiber Adapters Available (see page 44)	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC	NA
Version		V1			
Part number: Standard Sensor	**7Z02621**	**7Z02622**	**7Z02742**	**7Z02628**	**7Z02687**
BeamTrack Sensor: Beam, Posivtion & Size (p. 56)	**7Z07934**	**7Z07935**			
StarLink Sensor: Direct USB link to PC (p. 42)	**787000**	**787001**		**787002**	

Note: (a) Depending on room airflow and temperature variations

Note: (b) Remove window for measurement beyond 2.2µm

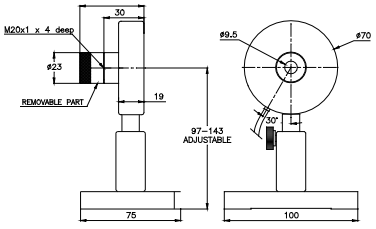
Note: (c) 2 sigma standard lab traceable for >0.6THz. For 0.5THz and below add 5% to error

Note: (d) Back reflections from meter can sometimes cause interference effects with source. Unit should be tilted ~10° in this case.

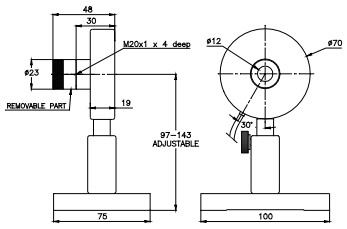
Note: (e) For P type and shorter wavelengths derate maximum energy density as follows:

Wavelength	Derate to value
1064nm	Not derated
532nm	Not derated
355nm	40% of stated value
266nm	10% of stated value
193nm	10% of stated value

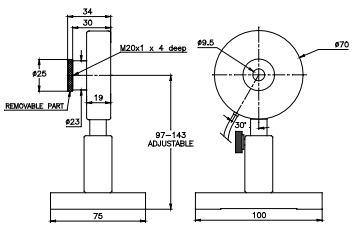
3A



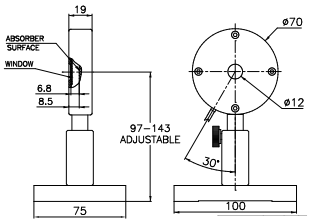
3A-P / 3A-P-THz



3A-FS



3A-P-FS-12



OPHIR Photonics A Newport Corporation Brand

1.1.2.1 High Sensitivity Thermal Sensors

2mW to 12W

Features

- Very low noise and drift to measure very low powers and energies
- Broadband and P absorbers for CW and short pulses
- Up to 12W
- Spectrally flat

12A/ 12A-P

Model	12A	12A-P	
Use	**General purpose**	**Short pulses**	
Absorber Type	Broadband	P type	
Spectral Range µm	0.19 - 20	0.15 - 8	
Aperture mm	φ 16mm	φ 16mm	
Power Mode			
Power Range	2mW - 12W	2mW - 12W	
Power Scales	12W to 20mW	12W to 20mW	
Power Noise Level	50µW	50µW	
Thermal Drift (30min) [a]	40 - 150µW	40 - 150µW	
Maximum Average Power Density kW/cm²	25	0.05	
Response Time with Meter (0-95%) typ. s	2.5	3.5	
Power Accuracy +/-%	3	3	
Linearity with Power +/-%	1.5	1.5	
Energy Mode			
Energy Range	1mJ - 30J	1mJ - 30J	
Energy Scales [b]	30J to 30mJ	30J to 30mJ	
Minimum Energy mJ	1	1	
Maximum Energy Density J/cm² [c]			
Pulse rate:		Single	10 - 30Hz
<100ns	0.3	10	1
0.5ms	5	10	1
2ms	10	10	1
10ms	30	10	1
Cooling	convection	convection	
Fiber Adapters Available (see page 44)	ST, FC, SMA, SC	ST, FC, SMA, SC	
Weight kg	0.35	0.35	
Version	V1		
Part number	**7Z02638**	**7Z02624**	

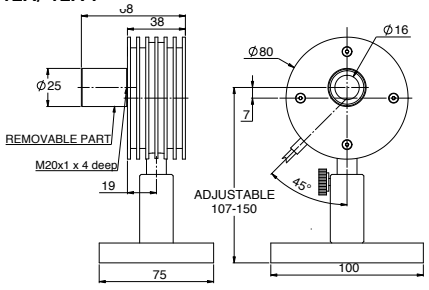
Notes: (a) Depending on room airflow and temperature variations

Notes: (b) For the 30mJ energy scale measurements it is recommended to use the screw on barrel supplied with the sensor to protect from direct air flow

Note: (c) For P type and shorter wavelengths derate maximum energy density as follows:

Wavelength	Derate to value
1064nm	Not derated
532nm	Not derated
355nm	40% of stated value
266nm	10% of stated value
193nm	10% of stated value

12A/ 12A-P



1.1.2.2 Low Power Thermal Sensors

20mW to 150W

Features

- Convection air cooled
- Broadband absorber
- φ16mm to φ26mm apertures
- Fast response time

10A

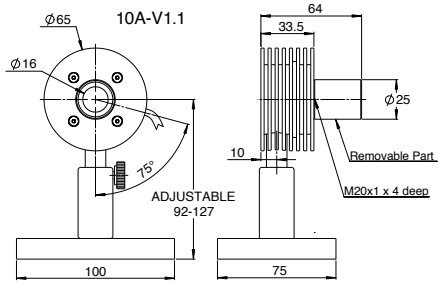
30A-BB-18

L30A-10MM

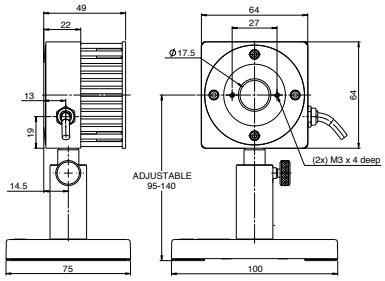
50(150)A-BB-26

Model	10A	30A-BB-18	L30A-10MM	50(150)A-BB-26
Use	**Low power**	**General purpose**	**Thin profile**	**General purpose**
Absorber Type	Broadband	Broadband	Broadband	Broadband
Spectral Range µm	0.19 - 20	0.19 - 20	0.15 - 20	0.19 - 20
Aperture mm	φ 16mm	φ 17.5mm	φ 26mm	φ 26mm
Power Mode				
Power Range	20mW - 10W	20mW - 30W	80mW - 30W	40mW - 150W
Maximum Power			8W free standing, 30W heat sinked	150W for 1.5min, 100W for 2.2min, 50W continuous
Power Scales	10W / 5W / 0.5W	30W / 5W	30W / 3W	150W / 50W / 5W
Power Noise Level	1mW	1mW	4mW	2mW
Maximum Average Power Density kW/cm²	28	20 at 30W 28 at 10W	20 at 30W 28 at 10W	12 at 150W 17 at 50W
Response Time with Meter (0-95%) typ. s	0.8	0.8	1.5	1.5
Power Accuracy +/-%	3	3	3	3
Linearity with Power +/-%	1	1	1	1.5
Energy Mode				
Energy Range	6mJ - 2J	6mJ - 30J	20mJ - 60J	20mJ - 100J
Energy Scales	2J / 200mJ	30J / 3J / 300mJ	60J / 20J /2J / 200mJ	100J / 30J / 3J / 300mJ
Minimum Energy mJ	6	6	20	20
Maximum Energy Density J/cm²				
<100ns	0.3	0.3	0.3	0.3
0.5ms	2	2	5	5
2ms	2	2	10	10
10ms	2	2	30	30
Cooling	convection	convection	convection / conduction	convection
Fiber Adapters Available (see page 44)	ST, FC, SMA, SC	ST, FC, SMA, SC	NA	ST, FC, SMA, SC
Weight kg	0.2	0.3	0.1	0.3
Version	V1.1			
Part number: Standard Sensor	**7Z02637**	**7Z02692**	**7Z02273**	**7Z02696**
BeamTrack Sensor: Beam, Position & Size (p. 56)	**7Z07904**			**7Z07900**
StarLink Sensor: Direct USB link to PC (p. 42)	**787004**	**787006**		

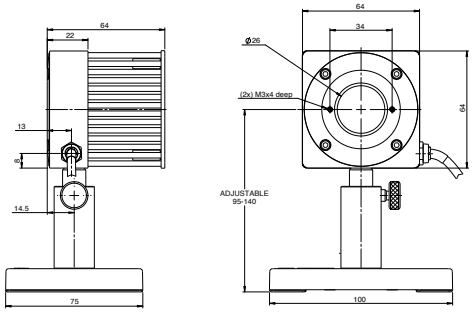
10A



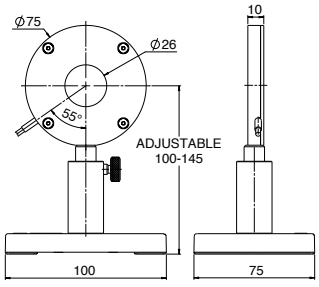
30A-BB-18



50(150)A-BB-26



L30A-10MM



1.1.2.2 Low Power Thermal Sensors

40mW to 50W

Features

- Convection air cooled
- P, PF and N type absorbers for short pulses
- φ16mm to 17.5mm apertures

10A-P

30A-P-17

15(50)A-PF-DIF-18

50A-PF-DIF-18

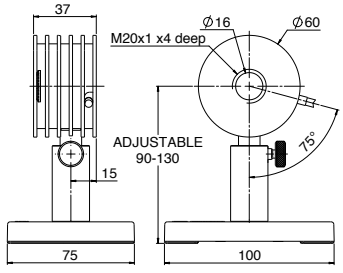
30A-N-18

Model	10A-P	30A-P-17	15(50)A-PF-DIF-18/ 50A-PF-DIF-18	30A-N-18
Use	**Short pulse to 10W**	**Short pulse to 30W**	**High energy density pulsed beams**	**High power density pulsed YAG**
Absorber Type	P type	P type	PF type + diffuser	N type
Spectral Range µm	0.15 - 8	0.15 - 8	0.24 - 2.2	0.532, 1.064
Aperture mm	φ 16mm	φ 17mm	φ 17.5mm	φ 17.5mm
Power Mode				
Power Range	40mW - 10W	60mW - 30W	140mW - 50W	60mW - 30W
Maximum Intermittent Power W	NA	NA	(for 15(50)A-PF-DIF-18 only) 50W for 5min, 15W continuous	NA
Power Scales	10W / 2W / 200mW and dBm	30W / 3W	50W / 5W	30W / 3W
Power Noise Level	2mW	3mW	7mW	3mW
Maximum Average Power Density kW/cm²	0.05	0.05	0.5	5
Response Time with Meter (0-95%) typ. s	3.5	2.5	2	2
Power Accuracy +/-%	3	3	5	3
Linearity with Power +/-%	1.5	1.5	1.5	1
Energy Mode				
Energy Range	10mJ - 10J	40mJ - 30J	60mJ - 200J	30mJ - 200J
Energy Scales	10J / 2J / 200mJ	30J / 3J	200J / 30J / 3J	200J / 30J / 3J
Minimum Energy mJ	10	40	60	30
Maximum Energy Density J/cm² (a)				
Pulse rate:	Single 10 - 30Hz	Single 10 - 30Hz	10 - 50Hz	10 - 50Hz
<1µs	10 1	10 1	4	1
0.5ms	10 1	10 1	15	20
5ms	10 1	10 1	50	>100
Cooling	convection	convection	convection	convection
Fiber Adapters Available (see page 44)	ST, FC, SMA, SC	ST, FC, SMA, SC	NA	ST, FC, SMA, SC
Weight kg	0.2	0.3	0.35	0.3
Version	V3			
Part number	**7Z02649**	**7Z02693**	**7Z02740/ 7Z02738**	**7Z02695**

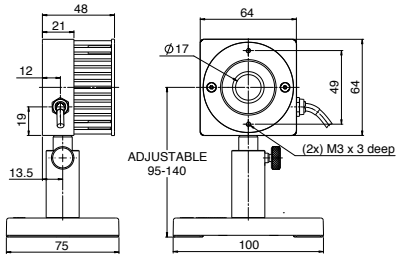
Note: (a) For shorter wavelengths derate maximum energy density as follows:

Wavelength	Derate to value	Wavelength	Derate to value
1064nm	Not derated	1064nm	Not derated
532nm	Not derated	532nm	80% of stated value
355nm	40% of stated value	355nm	60% of stated value
266nm	10% of stated value	266nm	40% of stated value
193nm	10% of stated value	193nm	NA

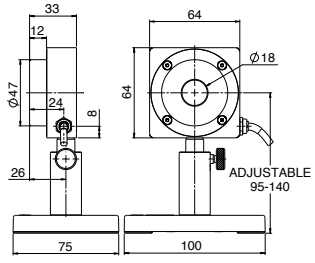
10A-P



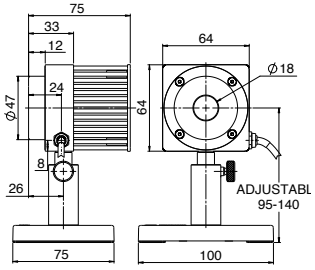
30A-P-17



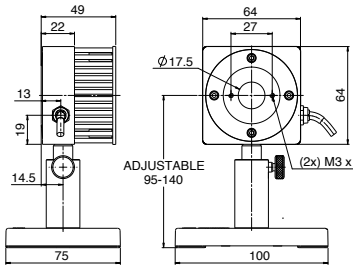
15(50)A-PF-DIF-18



50A-PF-DIF-18



30A-N-18



1.1.2.3 Low - Medium Power Thermal Sensors - Apertures to 35mm

30mW to 150W

Features

- Convection air cooled
- CW to 30W or 50W, intermittent to 150W
- φ17.5mm and φ35mm apertures

30(150)A-BB-18
30(150)A-LP1-18

L50(150)A-BB-35
L50(150)A-LP1-35
L50(150)A-PF-35

Model	**30(150)A-BB-18**	**30(150)A-LP1-18**	**L50(150)A-BB-35**	**L50(150)A-LP1-35**	**L50(150)A-PF-35**
Use	**General purpose**	**High power density and long pulse lasers**	**General purpose**	**High power density and long pulse lasers**	**Short pulse lasers**
Absorber Type	Broadband	LP1	Broadband	LP1	PF
Spectral Range µm	0.19 - 20	0.25 - 2.2	0.19 - 20	0.25 - 2.2	0.15-20
Aperture mm	φ 17.5mm	φ 17.5mm	φ 35mm	φ 35mm	φ 35mm
Power Mode					
Power Range	30mW - 150W	30mW - 150W	100mW - 150W	100mW - 150W	100mW - 150W
Maximum Intermittent Power W	150W for 1.5min, 100W for 2.2min, 30W continuous		150W for 1.5min, 100W for 2.5min, 50W continuous		
Power Scales	150W / 30W / 3W	150W / 30W / 3W	150W / 50W / 5W	150W / 50W / 5W	150W / 50W /5W
Power Noise Level	2mW	2mW	4mW	4mW	4mW
Maximum Average Power Density kW/cm²	12 at 150W 20 at 30W	38 at 150W 97 at 30W	12 at 150W 17 at 50W	38 at 150W 75 at 50W	3
Response Time with Meter (0-95%) typ. s	1.2	1.2	2	2	2
Power Accuracy +/-%	3	3 [(a)]	3	3 [(a)]	4
Linearity with Power +/-%	1	1	1	1	1
Energy Mode					
Energy Range	20mJ - 100J	20mJ - 300J	40mJ - 300J	40mJ - 300J	50mJ - 300J
Energy Scales	100J / 30J / 3J	300J / 30J / 3J	300J / 30J / 3J	300J / 30J / 3J	300J / 30J / 3J
Minimum Energy mJ	20	20	40	40	50
Maximum Energy Density J/cm²					Singel [(b)] 18-50Hz [(b)]
<100ns	0.3	0.05	0.3	0.05	3 [(c)] 1.5
0.5ms	5	20	5	20	7 7
2ms	10	50	10	50	15 15
10ms	30	250	30	250	40 40
Cooling	convection / ballistic	convection / ballistic	convection / ballistic	convection / ballistic	convection / ballistic
Fiber Adapters Available (see page 44)	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC
Weight kg	0.3	0.3	0.35	0.35	0.35
Version					
Part number: Standard Sensor	**7Z02699**	**7Z02721S**	**7Z02730**	**7Z02726S**	**7Z02737**
StarLink Sensor: Direct USB link to PC (p. 42)	**787007**				

Note:

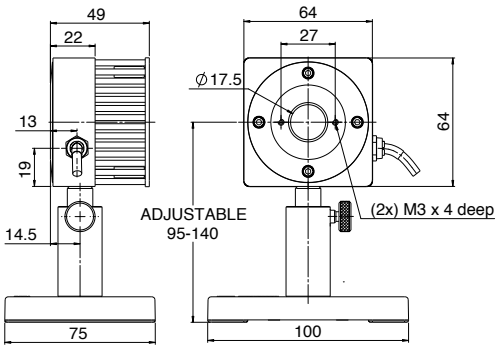
(a) LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. Nova and Orion meters do not support this feature and when used with those meters, accuracy will be ±3% for 532nm, 808nm, 1064nm and 2100nm and ±6% for other wavelengths in the spectral range 400 – 1100nm.

(b) For 10-50Hz, derate as follows:

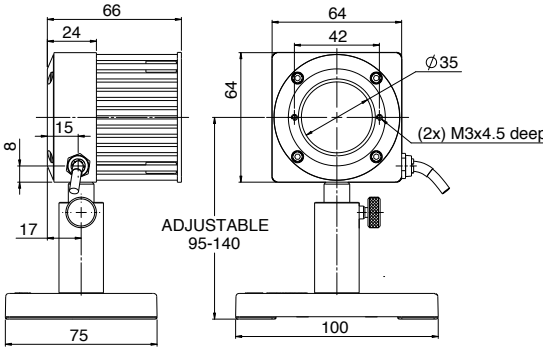
Wavelength	Derate to value
1064nm	Not derated
532n	Not derated
355n	70% of stated value
266nm	15% of stated value
193nm	10% of stated value

(c) Damage threshold 1.5J/cm² for wavelengths <500nm

30(150)A-BB-18 / 30(150)A-LP1-18



L50(150)A-BB-35 / L50(150)A-LP1-35 / L50(150)A-PF-35



1.1.2.3 Low - Medium Power Thermal Sensors - Apertures to 35mm

50mW to 150W

Features

- Special purpose SV and HE absorbers
- For concentrated beams and pulses
- Convection air cooled
- CW to 30W, intermittent to 150W
- φ17mm aperture

30(150)A-SV-17 / 30(150)A-HE-17

30(150)A-HE-DIF-17

Diffuser installed

Diffuser off

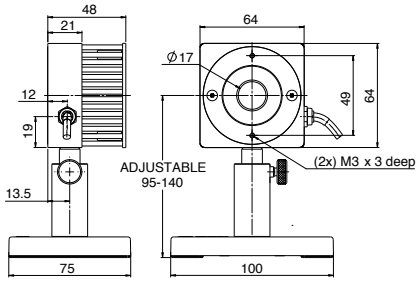
Model	**30(150)A-SV-17**			**30(150)A-HE-17**			**30(150)A-HE-DIF-17**		
Use	**High power and energy density**			**High energy and average power pulsed lasers**			**Concentrated beam pulsed lasers - has removable diffuser**		
Absorber Type	SV			HE			HE		
Spectral Range µm	0.19 - 12			0.19 - 0.625, 1.064, 2.1, 2.94			0.19 - 3 except for 0.625 - 0.9 (b)		
Aperture mm	φ 17mm			φ 17mm			φ 17mm		
Power Mode									
Power Range	100mW - 150W			50mW - 150W			50mW - 150W		
Maximum Intermittent Power W	150W for 1.5min, 100W for 2.2min, 30W continuous								
Power Scales	150W / 30W / 3W			150W / 30W / 3W			150W / 30W / 3W		
Power Noise Level	5mW			3mW			3mW		
Maximum Average Power Density kW/cm²	60 at 150W			0.5			0.5		
Response Time with Meter (0-95%) typ. s	1.7			3.8			3.8		
Power Accuracy +/-%	3			3			5 (b)		
Linearity with Power +/-%	1			1.5			1.5		
Energy Mode									
Energy Range	50mJ - 300J			60mJ - 200J			60mJ - 200J		
Energy Scales	300J / 30J / 3J			200J / 30J / 3J			200J / 30J / 3J		
Minimum Energy mJ	50			60			60		
Damage Threshold J/cm²	Pulse width (a)	Single	10-50Hz	Pulse width (a)	Single	10-50Hz	Pulse width <100ns, 10 - 50Hz		
							Wavelength	DIF IN	DIF OUT
	<100ns	1	1	<100ns	5	2	1064nm	5	2
	0.5ms	20	20	0.5ms	100	25	532nm	4	2
	2ms	50	50	2ms	150	40	355nm	1.5	1
Cooling	convection / ballistic			convection / ballistic			convection / ballistic		
Fiber Adapters Available (see page 44)	ST, FC, SMA, SC			ST, FC, SMA, SC			NA		
Weight kg	0.3			0.3			0.4		
Version									
Part number	**7Z02724**			**7Z02722**			**7Z02729**		

Notes:

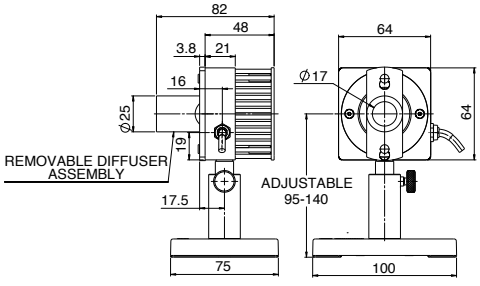
(a) At 1064nm. For shorter wavelengths derate maximum energy density to:
355nm 50% of above values
266nm 50% of above values
193nm 10% of above values

(b) With diffuser in, sensor is only calibrated for 1064, 532 and 355nm wavelengths.

30(150)A-SV-17 / 30(150)A-HE-17



30(150)A-HE-DIF-17



1.1.2.4 Medium Power Large Aperture Thermal Sensors - Apertures 50mm

100mW to 150W

Features

- Thin profile
- CW to 35W or 50W, intermittent to 150W
- 50mm aperture
- For continuous, long pulse and excimer lasers

L40(150)A / L40(150)A -LP1

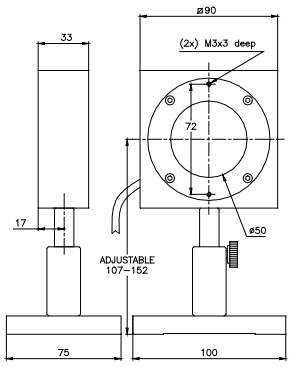
L40(150)A -EX

L50(150)A

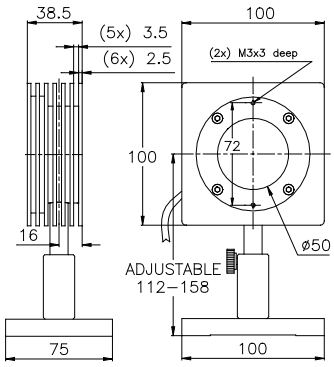
Model	L40(150)A	L40(150)A-LP1	L40(150)A-EX	L50(150)A
Use	**General purpose**	**Long pulse lasers**	**Excimer lasers**	**General purpose**
Absorber Type	Broadband	LP1	EX	Broadband
Spectral Range µm	0.19 - 20	0.25 - 2.2, 2.94	0.15 - 0.7, 10.6	0.19 - 20
Aperture mm	φ 50mm	φ 50mm	φ 50mm	φ 50mm
Power Mode				
Power Range	100mW - 150W	100mW - 150W	100mW - 150W	100mW - 150W
Maximum Intermittent Power	150W for 3min, 80W for 5.5min, 35W continuous			150W for 4min, 100W for 6min, 50W continuous
Power Scales	150W / 20W	150W / 20W	150W / 20W	150W / 20W
Power Noise Level	5mW	10mW	5mW	5mW
Maximum Average Power Density kW/cm²	12 at 150W 20 at 35W	38 at 150W 90 at 35W	2	12 at 150W 17 at 50W
Response Time with Meter (0-95%) typ. s	2.5	2.5	2.5	2.5
Power Accuracy +/-%	3	3 [(a)]	3	3
Linearity with Power +/-%	1	1	1	1
Energy Mode				
Energy Range	100mJ - 200J	100mJ - 300J	100mJ - 200J	100mJ - 300J
Energy Scales	200J / 30J / 3J	300J / 30J / 3J	200J / 30J / 3J	300J / 30J / 3J
Minimum Energy mJ	100	100	100	100
Maximum Energy Density J/cm²				
<100ns	0.3	0.05	0.5	0.3
1µs	0.5	0.3	0.6	0.5
0.5ms	5	20	6	5
2ms	10	50	12	10
10ms	30	250	25	30
Cooling	convection / ballistic	convection / ballistic	convection / ballistic	convection / ballistic
Fiber Adapters Available (see page 44)	ST, FC, SMA, SC	ST, FC, SMA, SC	NA	ST, FC, SMA, SC
Weight kg	0.6	0.6	0.6	0.6
Version	V2	V2	V1	
Part number: Standard Sensor	**7Z02626**	**7Z02685S**	**7Z02614**	**7Z02633**
StarLink Sensor: Direct USB link to PC (p. 42)				**787003**

Notes: (a) LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. Nova and Orion meters do not support this feature and when used with those meters, accuracy will be ±3% for 532nm, 808nm, 1064nm and 2940nm and ±6% for other wavelengths in the spectral range 400 – 1100nm.

L40(150)A / L40(150)A -LP1 / L40(150)A -EX



L50(150)A



1.1.2.4 Medium Power Large Aperture Thermal Sensors - Apertures 65mm

400mW to 300W

Features

- Thin profile, very large aperture
- CW to 50W, intermittent to 300W
- φ65mm aperture
- IPL version for IPL medical light sources

L50(300)A / L50(300)A-LP1 / L50(300)A-PF-65

L50(300)A-IPL

Model	L50(300)A	L50(300)A-LP1	L50(300)A-PF-65	L50(300)A-IPL
Use	**General purpose**	**Long pulse lasers**	**Large beam short pulsed lasers**	**Intense pulsed light sources**
Absorber Type	Broadband	LP1	PF type	LP1 + coated window [b]
Spectral Range µm	0.19 - 20	0.25 - 2.2	0.15 - 20	0.5 - 1.1
Aperture mm	φ 65mm	φ 65mm	φ 65mm	φ 65mm
Power Mode				
Power Range	400mW - 300W	400mW - 300W	400mW - 300W	400mW - 300W
Maximum Intermittent Power		300W for 2min, 150W for 4.5min, 50W continuous		
Power Scales	300W / 30W	300W / 30W	300W / 30W	300W / 30W
Power Noise Level	20mW	20mW	20mW	20mW
Maximum Average Power Density kW/cm²	9 at 300W 17 at 50W	23 at 300W 75 at 50W	3	20
Response Time with Meter (0-95%) typ. s	3	3	3	3
Power Accuracy +/-%	3	3 [a]	3	6 for most gel or air coupled IPL sources
Linearity with Power +/-%	1	1	1	1
Energy Mode				
Energy Range	200mJ - 300J	200mJ - 300J	200mJ - 300J	120mJ - 300J
Energy Scales	300J / 60J / 6J	300J / 60J / 6J	300J / 60J / 6J	300J / 60J / 6J
Minimum Energy mJ	200	200	200	120
Maximum Energy Density J/cm²			Single [C] 10-50Hz [C]	
<100ns	0.3	0.05	3 [d] 1.5	0.05
1µs	0.5	0.3	3 [d] 1.5	0.3
0.5ms	5	20	7 7	20
2ms	10	40	15 15	40
10ms	30	100	40 40	100
Cooling	convection / ballistic	convection / ballistic	convection / ballistic	convection / ballistic
Weight kg	0.9	0.9	0.9	1.0
Version		V1		
Part number	**7Z02658**	**7Z02641S**	**7Z02743**	**7Z02651**

Notes:

(a) LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. Nova and Orion meters do not support this feature and when used with those meters, accuracy will be ±3% for 532nm, 808nm, 1064nm and 2100nm and ±6% for other wavelengths in the spectral range 400 – 1100nm.

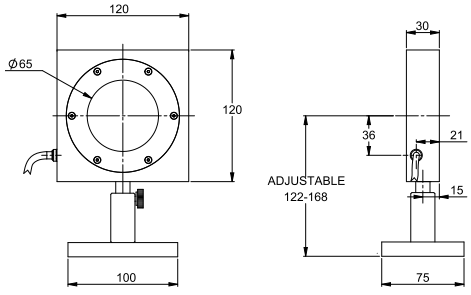
(c) For 10-50Hz, derate as follows:

Wavelength	Derate to value
1064nm	Not derated
532nm	Not derated
355nm	70% of stated value
266nm	15% of stated value
193nm	10% of stated value

(d) Damage threshold 1.5J/cm² for wavelengths <500nm

(b) Sensor has a window for gel coupled IPL sources where IPL source is coupled to window with gel or water for measurement. Can also measure air coupled IPLs

L50(300)A / L50(300)A-LP1 / L50(300)A-PF-65 / L50(300)A-IPL



1.1.2.5 Medium-High Power Fan Cooled Thermal Sensors

50mW to 250W

Features

- General purpose and high damage threshold
- Fan cooled
- Up to 250W
- φ17.5mm to φ35mm apertures

F100A-PF-DIF-18

F150A-BB-26

FL250A-BB-35 / FL250A-LP1-35

FL250A-LP1-DIF-33

Model	F100A-PF-DIF-18 / F100A-PF-DIF-33	F150A-BB-26	FL250A-BB-35	FL250A-LP1-35	FL250A-LP1-DIF-33
Use	**Short pulse lasers**	**General purpose**	**General purpose**	**High power density and long pulse lasers**	**Diffuser for highest energy densities**
Absorber Type	PF type + diffuser	Broadband	Broadband	LP1	LP1 + diffuser
Spectral Range µm	0.24-2.2	0.19 - 20	0.19 - 20	0.25 - 2.2	0.4 - 3
Aperture mm	φ 17.5mm / φ 33mm	φ 26mm	φ 35mm	φ 35mm	φ 33mm
Power Mode					
Power Range (d)	50mW - 100W	50mW - 150W	150mW - 250W	150mW - 250W	400mW - 250W
Power Scales	100W / 30W / 3W	150W / 30W / 3W	250W / 30W	250W / 30W	250W / 30W
Power Noise Level (d)	6mW	3mW	15mW	15mW	20mW(e)
Maximum Average Power Density kW/cm²	0.5	12 at 150W 17 at 50W	10 at 250W 12 at 150W	27 at 250W 39 at 150W	2
Response Time with Meter (0-95%) typ. s	2 / 2.5	1.5	2	2	2.5
Power Accuracy +/-%	5	3	3	3 (c)	3 (b)
Linearity with Power +/-%	1.5	1	1	1	1.5
Energy Mode					
Energy Range	60mJ - 200J	20mJ - 100J	50mJ - 300J	50mJ - 300J	400mJ - 600J
Energy Scales	200J / 30J / 3J	100J / 30J / 3J / 300mJ	300J / 30J / 3J	300J / 30J / 3J	600J / 60J
Minimum Energy mJ (d)	60	20	50	50	400
Maximum Energy Density J/cm²					
<100ns	4(a)	0.3	0.3	0.05	0.5
0.5ms	15(a)	5	5	20	200
2ms	35(a)	10	10	50	400
10ms	50(a)	30	30	250	1000
Cooling	fan	fan	fan	fan	fan
Fiber Adapters Available (see page 44)	NA	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC	NA
Weight kg	0.4 / 0.8	0.35	0.4	0.4	0.45
Version					
Part number: Standard Sensor	**7Z02741 / 7Z02744**	**7Z02727**	**7Z02728**	**7Z02731S**	**7Z02733**
BeamTrack Sensor: Beam, Position & Size (p.57/58)		**7Z07901**			

Notes: (a) For shorter wavelengths derate maximum energy density as follows:

Wavelength	Derate to value
1064nm	not derated
532nm	80% of stated value
355nm	60% of stated value
266nm	40% of stated value
193nm	NA

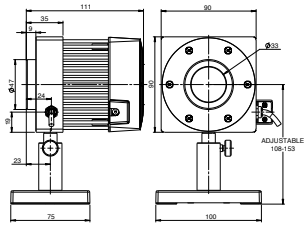
Notes: (b) at calibrated wavelengths 755nm, 1064nm and 532nm only

Notes: (e) When sensor is hot, there can be large zero offset up to 300mW

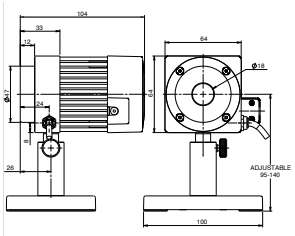
Notes: (c) LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. Nova and Orion meters do not support this feature and when used with those meters, accuracy will be ±3% for 532nm, 808nm, 1064nm and 2100nm and ±6% for other wavelengths in the spectral range 400 – 1100nm.

Notes: (d) For lower powers up to 30W it is recommended to work with the fan off and then the noise level is ~3 times lower. It is also recommended to measure energy with the fan off.

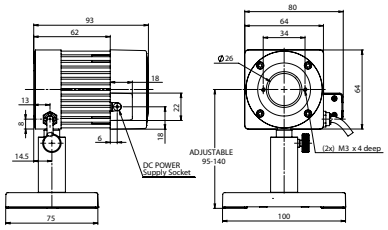
F100A-PF-DIF-33



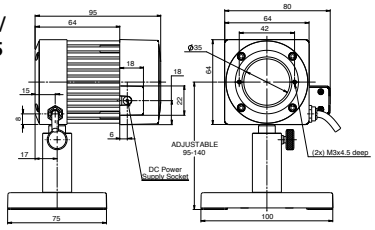
F100A-PF-DIF-18



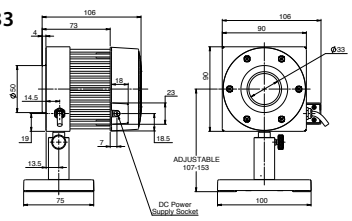
F150A-BB-26



FL250A-BB-35 / FL250A-LP1-35



FL250A-LP1-DIF-33



OPHIR Photonics
A Newport Corporation Brand

1.1.2.5 Medium-High Power Fan Cooled Thermal Sensors

150mW to 500W

Features

- High powers and energies, large apertures
- Fan cooled
- Up to 500W
- φ50mm and φ65mm apertures

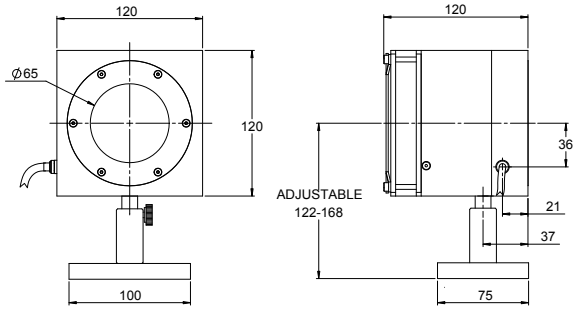
FL250A-BB-50 / FL400A-BB-50 / FL400A-LP-50

FL500A / FL500A-LP1

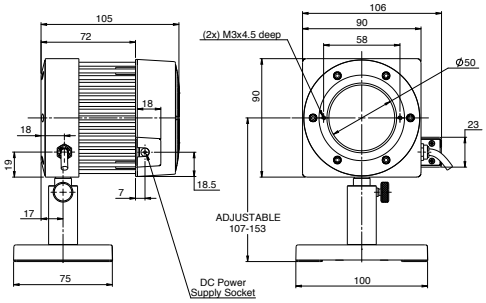
Model	FL250A-BB-50	FL400A-BB-50	FL400A-LP-50	FL500A	FL500A-LP1
Use	**General purpose**	**General purpose**	**High power densities and long pulses**	**Very large aperture**	**High power densities and long pulses**
Absorber Type	Broadband	Broadband	LP	Broadband	LP1
Spectral Range µm	0.19-20	0.19 - 20	0.4 - 1.5, 10.6	0.19 - 20	0.25 - 2.2
Aperture mm	φ 50mm	φ 50mm	φ 50mm	φ 65mm	φ 65mm
Power Mode					
Power Range [a]	150mW - 250W	300mW - 400W	300mW - 400W	500mW - 500W	500mW - 500W
Power Scales	250W / 30W	400W / 50W	400W / 50W	500W / 50W	500W / 50W
Power Noise Level [a]	10mW	40mW	40mW	25mW	25mW
Maximum Average Power Density kW/cm²	10 at 250W 12 at 150W	8 at 400W 12 at 150W	10 at 400W 14 at 150W	7 at 500W 12 at 150W	16 at 500W 39 at 150W
Response Time with Meter (0-95%) typ. s	2.5	2.8	2.8	2.8	2.8
Power Accuracy +/-%	3	3	3	3	3[b]
Linearity with Power +/-%	1	1.5	1.5	1.5	1.5
Energy Mode					
Energy Range	80mJ - 300J	75mJ - 600J	75mJ - 600J	100mJ - 600J	100mJ - 600J
Energy Scales	300J / 30J / 3J	600J / 60J / 6J	600J / 60J / 6J	600J / 60J / 6J	600J / 60J / 6J
Minimum Energy mJ [a]	80	75	75	100	100
Maximum Energy Density J/cm²					
<100ns	0.3	0.3	0.05	0.3	0.05
1µs	0.5	0.5	0.3	1	0.3
0.5ms	5	5	20	5	15
2ms	10	10	50	10	40
10ms	30	30	150	30	200
Cooling	fan	fan	fan	fan	fan
Fiber Adapters Available (see page 44)	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC	NA	NA
Weight kg	0.8	0.9	0.9	2.7	2.7
Version					
Part number: Standard Sensor	**7Z02739**	**7Z02734**	**7Z02735**	**7Z02648**	**7Z02667S**
BeamTrack Sensor: Beam, Position & Size (p.58)	**7Z07902**				

Notes: (a) For lower powers up to 50W it is recommended to work with the fan off and then the noise level is ~3 times lower. It is also recommended to measure energy with the fan off.
Notes: (b) LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. Nova and Orion meters do not support this feature and when used with those meters, accuracy will be ±3% for 532nm, 808nm, 1064nm and 2100nm and ±6% for other wavelengths in the spectral range 400-1100nm.

FL500A / FL500A-LP1



FL250A-BB-50 / FL400A-BB-50 / FL400A-LP-50



1.1.2.6 High Power Water Cooled Thermal Sensors and Power Pucks

1W to 300W

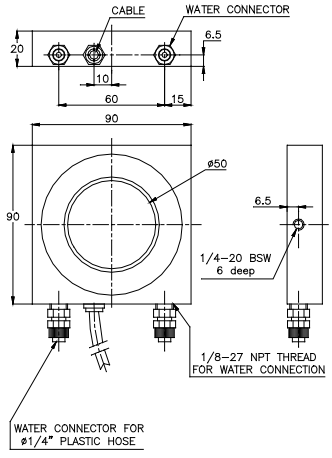
Features

- High powers
- Water cooled
- Up to 300W
- φ50mm aperture

L250W / L300W-LP

Model	L250W	L300W-LP
Use	**General purpose**	**High power densities and long pulses**
Absorber Type	Broadband	LP
Spectral Range µm	0.19 - 20	0.4 - 1.5, 10.6
Aperture mm	φ 50mm	φ 50mm
Power Mode		
Power Range	1W - 250W	4W - 300W
Power Scales	250W / 30W	300W / 30W
Power Noise Level	50mW	200mW
Maximum Average Power Density kW/cm²	10 at 250W 14 at 100W	11 at 300W 14 at 150W
Response Time with Meter (0-95%) typ. s	2.5	2.5
Power Accuracy +/-%	3	3 (a)
Linearity with Power +/-%	2	2
Energy Mode		
Energy Range	120mJ - 200J	200mJ - 300J
Energy Scales	200J / 30J / 3J	300J / 30J / 3J
Minimum Energy mJ	120	200
Maximum Energy Density J/cm²		
<100ns	0.3	0.05
1µs	0.5	0.3
0.5ms	5	20
2ms	10	50
10ms	30	150
Cooling	water	water
Minimum Water Flow Rate at Full Power	1 liter/min (b)	1 liter/min (b)
Weight kg	0.6	0.6
Version		
Part number	**7Z02688**	**7Z02689**
Notes: (a)	Calibrated for 1.064µm and 10.6µm	
Notes: (b)	Water temperature range 18-30°C. Water temperature rate of change <1°C/min.	

L250W / L300W-LP



1.1.2.6 High Power Water Cooled Thermal Sensors and Power Pucks

5W to 1500W

Features

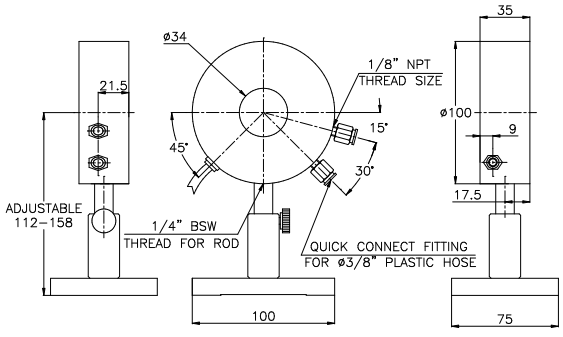
- High powers
- Water cooled
- Up to 1500W
- φ34mm and φ50mm apertures

1000W / 1000W-LP

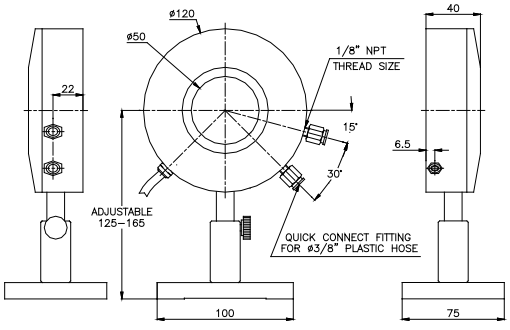
L1500W / L1500W-LP

Model	1000W	1000W-LP	L1500W	L1500W-LP
Use	**General purpose**	**High power densities and long pulses**	**General purpose**	**High power densities and long pulses**
Absorber Type	Broadband	LP	Broadband	LP
Spectral Range µm	0.19 - 20	0.4 - 1.5, 10.6	0.19 - 20	0.4 - 1.5, 10.6
Aperture mm	φ 34mm	φ 34mm	φ 50mm	φ 50mm
Power Mode				
Power Range	5W - 1000W	5W - 1000W	15W - 1500W	15W - 1500W
Power Scales	1000W / 200W	1000W / 200W	1500W / 300W	1500W / 300W
Power Noise Level	200mW	200mW	700mW	700mW
Maximum Average Power Density kW/cm²	7.5 at 500W 6 at 1000W	9 at 500W 7 at 1000W	7.5 at 500W 5 at 1500W	9 at 500W 6 at 1500W
Response Time with Meter (0-95%) typ. s	2.5	2.5	2.7	2.7
Power Accuracy +/-%	3 (a)	3 (a)	4 (a)	4 (a)
Linearity with Power +/-%	2	2	2	2
Energy Mode				
Energy Range	300mJ - 300J	300mJ - 300J	500mJ - 200J	500mJ - 200J
Energy Scales	300J / 30J	300J / 30J	200J / 20J	200J / 20J
Minimum Energy mJ	300mJ	300mJ	500mJ	500mJ
Maximum Energy Density J/cm²				
<100ns	0.3	0.05	0.3	0.05
1µs	0.4	0.3	0.4	0.3
0.5ms	5	20	5	20
2ms	10	50	10	50
10ms	30	150	30	150
Cooling	water	water	water	water
Minimum Water Flow Rate at Full Power	1.8 liter/min (b)	1.8 liter/min (b)	2.5 liter/min (b)	2.5 liter/min (b)
Weight kg	0.8	0.8	1.2	1.2
Version	V2	V2	V1	V1
Part number: Standard Sensor	**7Z02664**	**7Z02668**	**7Z02661**	**7Z02665**
StarLink Sensor: Direct USB link to PC (p. 42)	**787005**			
Notes: (a)	Calibrated for ~0.8µm 1.064µm and 10.6µm	Calibrated for 1.064µm and 10.6µm	Calibrated for ~0.8µm 1.064µm and 10.6µm	Calibrated for 1.064µm and 10.6µm
Notes: (b)	Water temperature range 18-30°C. Water temperature rate of change <1°C/min.			

1000W / 1000W-LP



L1500W / L1500W-LP



1.1.2.6 High Power Water Cooled Thermal Sensors and Power Pucks

100W to 30kW

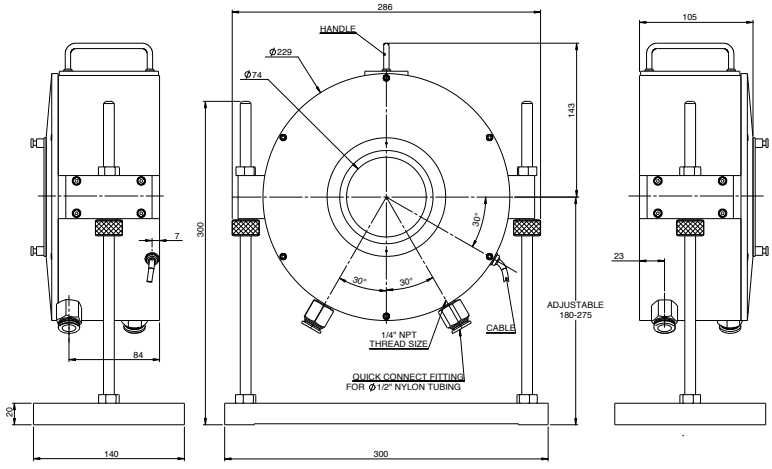
Features

- Highest powers
- Water cooled
- Up to 30kW
- φ74mm apertures

30K-W

Model	**30K-W**
Use	**Highest powers to 30kW**
Absorber Type	Beam deflector + broadband absorber
Spectral Range µm	0.8 – 2, 10.6µm (a)
Aperture mm	φ74mm
Power Range	100W – 30kW
Power Scales	30kW / 6kW / 600W
Power Noise Level	1W
Backscattered Power	Approximately 4%
Maximum Average Power Density kW/cm²	10kW/cm² anywhere in the beam (c)
Response Time with Display (0-95%) typ. s	7s
Power Accuracy +/-%	5 (a)
Linearity with Power +/-%	2
Cooling	Water (b)
Minimum Water Flow Rate at Full Power	25 liter/min
Water Pressure Requirements	Pressure drop across sensor ~0.2MPa. Pressure drop across 8 meters of ½" tubing with 9.5mm ID is ~0.3MPa
Water Connectors	Quick connector for ½" OD, 3/8" ID nylon tubing
Cable Length	10 meters
Weight Kg	19
Version	V1
Part number	**7Z02746**
Notes: (a)	Calibrated for 1.07µm
Notes: (b)	Water inlet temperature range 15-20°C. Water temperature rate of change <1°C/min.
Notes: (c)	For beam centered within ¼ of beam diameter. IMPROPERLY CENTERED BEAM CAN CAUSE DAMAGE TO SENSOR. Maximum tilt angle ±5 degrees.

30K-W



1.1.2.6 High Power Water Cooled Thermal Sensors and Power Pucks

20W to 10kW

Features

- Highest powers
- Water cooled
- Up to 10kW
- φ45mm and φ50mm apertures

5000W / 5000W-LP

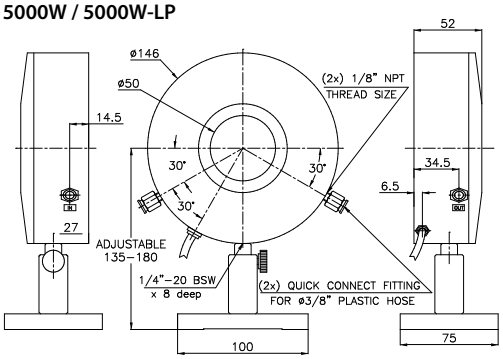
10K-W

Model	5000W	5000W-LP	10K-W
Use	**General purpose**	**High power densities and long pulses**	**Highest powers and power densities**
Absorber Type	Broadband	LP	Beam deflector + broadband absorber
Spectral Range µm	0.19 - 20	0.4 - 1.5, 10.6	0.8 - 2, 10.6
Aperture mm	φ 50mm	φ 50mm	φ45mm
Power Mode			
Power Range	20W - 5000W	20W - 5000W	100W - 10kW
Power Scales	5000W / 500W	5000W / 500W	10kW / 1kW
Power Noise Level	1W	1W	2W
Maximum Average Power Density kW/cm²	6 at 1000W 3 at 5000W	7 at 1000W 4 at 5000W	See note (c) below
Response Time with Meter (0-95%) typ. s	3	3	2.7
Power Accuracy +/-%	5 (a)	5 (a)	5 (a)
Linearity with Power +/-%	2	2	2
Energy Mode			
Energy Range	NA	NA	NA
Energy Scales	NA	NA	NA
Minimum Energy mJ	NA	NA	NA
Maximum Energy Density J/cm²			See note (c) below
<100ns	0.3	0.05	
1µs	0.4	0.3	
0.5ms	5	20	
2ms	10	50	
10ms	30	150	
Cooling	water	water	water
Minimum Water Flow Rate at Full Power	4.5 liter/min (b)	4.5 liter/min (b)	9 liter/min (b)
Weight kg	2.8	2.8	4.5
Version			V1
Part number	**7Z02119**	**7Z02255**	**7Z02645**
Notes: (a)	Calibrated for ~0.8µm 1.064µm and 10.6µm	Calibrated for 1.064µm and 10.6µm	Calibrated for 1.064µm and 10.6µm
Notes: (b)	Water temperature range 18-30°C. Water temperature rate of change <1°C/min.		

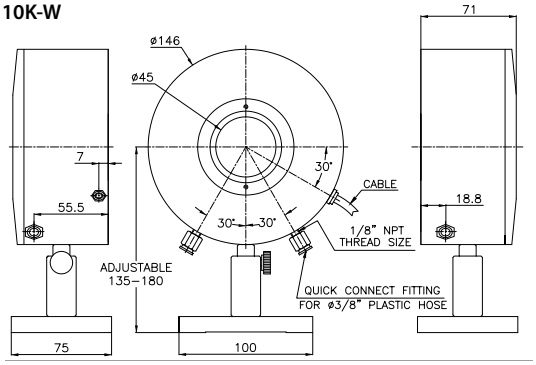
Notes: (c)

Beam diameter	Max power density	Max energy density		
		1ms pulse width	3ms pulse width	10ms pulse width
<15mm	10kW/cm²	30J/cm²	60J/cm²	150J/cm²
15 - 20mm	7kW/cm²	20J/cm²	40J/cm²	100J/cm²
20 - 40mm	5kW/cm²	15J/cm²	30J/cm²	70J/cm²
40 - 45mm	4kW/cm²	12J/cm²	25J/cm²	60J/cm²

5000W / 5000W-LP



10K-W



1.1.2.6 High Power Water Cooled Thermal Sensors and Power Pucks

20W to 10kW

Features

- Comet power pucks measure heat rise from 10s exposure to laser
- Accurate, built in temperature compensation algorithm.
- Up to 10kW
- Up to 100mm apertures

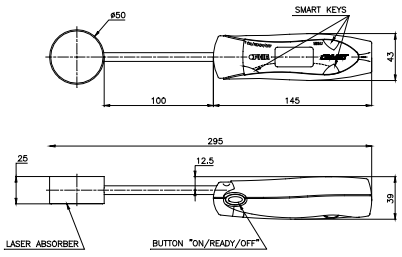
Comet 1K

Comet 10K

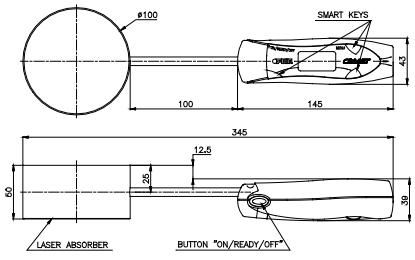
Comet 10K-HD

Model	Comet 1K		Comet 10K		Comet 10K-HD		
Use	**For powers to 1kW**		**For powers to 10kW**		**For high power density beams**		
Absorber Type	Broadband		Broadband		Broadband with reflective cone beam spreader		
Spectral Range µm	0.2 - 20		1.06 and 10.6		1.06 and 10.6		
Aperture mm	φ50mm		φ100mm		φ55mm		
Power Mode							
Power Range	20W to 1kW		200W to 10kW		200W to 10kW		
Repeatability			±1% for same initial temperature				
Maximum Average Power Density kW/cm²	Power	1K Model	Power	Damage Threshold	Power	Beam dia <40	Beam dia >40
	100W	10	1kW	3.5	1kW	10	7
	200W	8	2kW	2.8	2kW	10	6
	300W	6	3kW	2.5	3kW	8	5
	500W	5	5kW	1.5	5kW	6	3
	1kW	4	10kW	1	10kW	4	2
Power Accuracy +/-%	5		5		5		
Linearity with Power +/-%	±2% ±1W from 20W to 1kW		±2% from 1kW to 10kW		±2% from 1kW to 10kW		
Number of readings before probe must be cooled (for 25°C starting temp.)	100W	4	1kW	4	1kW	4	
	300W	3	3kW	3	3kW	3	
	400W	2	4kW	2	4kW	2	
	1kW	1	10kW	1	10kW	1	
Maximum Energy Density J/cm²							
<100ns	0.3		0.3		1		
10µs	1		1		3		
1ms	10		10		30		
10ms	50		50		150		
Time to Reading	Initial reading 10s after exposure, final reading 20s after exposure		Initial reading 20s after exposure, final reading 40s after exposure		Initial reading 30s after exposure, final reading 70s after exposure		
Temperature Compensation	Temperature compensated to give accurate readings independent of starting probe temperature						
Maximum Permitted Probe Temperature	70°C before measurement, 140°C after measurement						
Display	2x8 character LCD. Character height 5mm. CE Approved.						
Operation Mode	AUTO: Automatic measurement with laser set to 10s timed exposure. Unit senses temperature rise and measures automatically. MANUAL: User places probe in front of beam for 10s. Unit beeps to indicate start and stop measurement points. History: Stores last three readings. Calibration: Can be recalibrated by user.						
Battery	2 x AA. Lifetime in normal use approximately 1 year.						
Weight kg	0.3		1.2		1.2		
Version			V1		V2		
Part number	**7Z02702**		**7Z02705**		**7Z02706**		

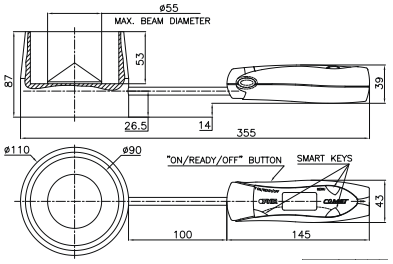
Comet 1K



Comet 10K



Comet 10K-HD



1.1.3 StarLink Direct to PC Power Sensors

The StarLink Power Sensor Series

The StarLink series is a select group of Ophir power sensors that are provided with the Ophir Juno USB PC interface attached. The StarLink sensor is connected via a USB cable to the PC USB port and can then operate directly with the PC with no need for an Ophir power meter.

The StarLink package comes bundled with the celebrated Ophir StarLab software – the easiest to use and most sophisticated power/energy meter PC software available. Alternatively, StarLink sensors can be operated from the user's software via the COM Object interface provided or can work with LabVIEW via the drivers provided.

For more details about the computer interface options and StarLab softwrare, see section 2.3.1 on page 105.

Below is a list of the StarLink power sensors currently available together with the reference page for the specifications on the relevant sensor.

StarLink Sensor	StarLink P/N	Corresponding stand alone sensor	Ophir P/N	Data sheet page
PD300-StarLink	787100	PD300	7Z02410	22
3A-StarLink	787000	3A	7Z02621	28
3A-QUAD-StarLink	787203	3A-QUAD	7Z07934	56
3A-P-StarLink	787001	3A-P	7Z02622	28
3A-FS-StarLink	787002	3A-FS	7Z02628	28
10A-StarLink	787004	10A	7Z02637	30
10A-PPS-StarLink	787202	10A-PPS	7Z07904	56
30A-BB-18-StarLink	787006	30A-BB-18	7Z02692	30
50(150)A-BB-26-PPS-StarLink	787200	50(150)A-BB-26-PPS	7Z07900	57
30(150)A-BB-18-StarLink	787007	30(150)A-BB-18	7Z02699	32
L50(150)A-StarLink	787003	L50(150)A	7Z02633	34
FL250A-BB-50-PPS-StarLink	787201	FL250A-BB-50-PPS	7Z07902	58
1000W-StarLink	787005	1000W	7Z02664	39

1.1.4 Power Sensors Accessories

1.1.4.1 Accessories for PD300 Sensors

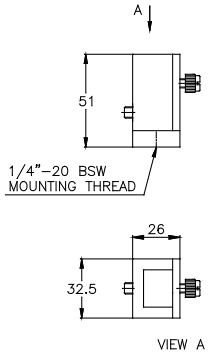
(For PD300R, PD300-IRG and 3A-IS series, see page 44)

Fiberoptic Adapters

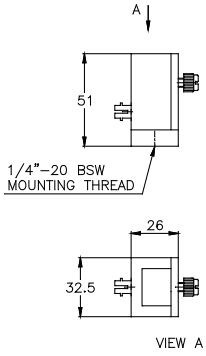
PD300 with F.O. Adapter Mounted

Accessory	Description	Part number			
PD300-CDRH	φ7mm aperture adapter for CDRH measurements	7Z02418			
Fiber Adapters	Adapters for mounting fibers to PD300 sensors as shown below	SC type	ST type	FC, FC/APC type	SMA type
PD300 F.O. Adapter		7Z08221	7Z02210	7Z02213	7Z02212

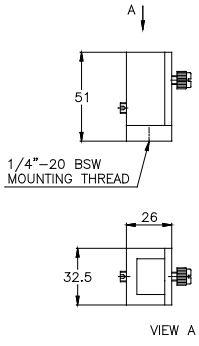
PD300-FO-SMA



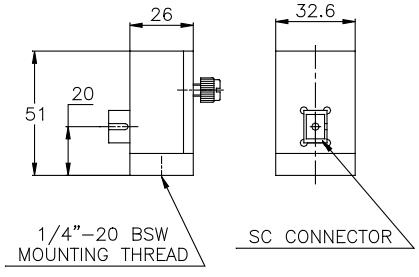
PD300-FO-ST



PD300-FO-FC



PD300-FO-SC



1.1.4.2 Accessories for Thermal Sensors, PD300R, PD300-IRG, 3A-IS and FPS-1

Fiberoptic Adapters and Voltage Converter

SC fiber adapter

ST fiber adapter

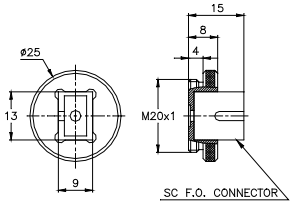
FC fiber adapter

SMA fiber adapter

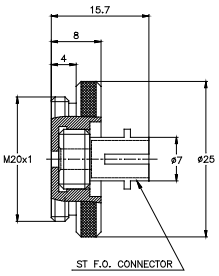
Sensor Series	Fiber adapter mounting bracket (1 bracket fits all fiber adapters)	SC fiber adapter	ST fiber adapter	FC, FC/APC fiber adapter	SMA fiber adapter
Thermal Sensors					
3A / 3A-QUAD / 3A-P / 3A-P-QUAD / 3A-FS / 3A-P-THz	not needed	7Z08227	7Z08226	7Z08229	1G01236
10A / 10A-PPS / 10A-P	not needed				
12A / 12A-P	not needed				
30A-BB-18 / 30A-N-18	7Z08211				
50(150)A-BB-26 / 50(150)A-BB-26-PPS / F150A-BB-26 / F150A-BB-26-PPS	7Z08210				
L50(150)A-BB-35 / L50(150)A-LP1-35 / L50(150)A-PF-35	7Z08265				
30A-P-17 / 30(150)A-SV-17 / 30(150)A-HE-17	7Z08230				
30(150)A-BB-18 / 30(150)A-LP1-18	7Z08211				
L40(150)A / L40(150)A-LP1 / L50(150)A	7Z08238 [(a)]				
FL250A-BB-35 / FL250A-BB-50-PPS / FL250A-LP1-35	7Z08265				
FL400A-BB-50 / FL250A-BB-50	7Z08212				
Photodiode Sensors					
PD300R series and FPS-1	1G02259	7Z08227	7Z08226	7Z08229	1G01236
3A-IS / 3A-IS-IRG	7Z08213	7Z08227	7Z08226	7Z08229	1G01236
PD300-IRG	not needed			7Z08216	7Z08222
General Accessories					
SH to BNC Adapter	Allows connection of sensor to voltage measuring device for measurement of raw voltage output.				7Z11010
IR Phosphor Card	Glass slide (75x25mm) with phosphor coating (25x50mm) that visualizes spectral region 810-860nm, 900-1100nm and 1500-1600nm. Stands up to 1kW/cm^2 and 0.5J/cm^2. Self actuating, does not need charging from light source.				7F01235A
Female SM1 to SM1 Adapter	For mounting PD300R and FPS-1 to SM1 optical components and systems				1G02260

Note: (a) The fiber mounting bracket for these sensors is a triple adapter for mounting up to three different fibers looking at same spot

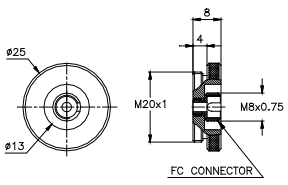
SC fiber adapter



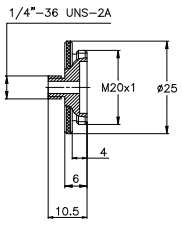
ST fiber adapter



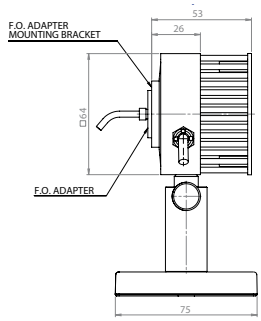
FC fiber adapter



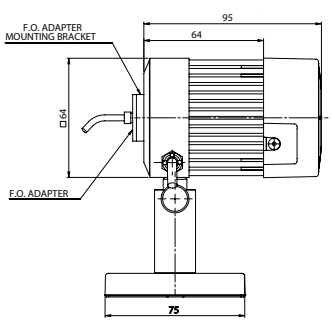
SMA fiber adapter



30A with F.O. input



FL250A with F.O. input



SM1 to M20 Adapter Mounting Bracket for PD300R Series and FPS-1, P/N 1G02259

Allows PD300R models to be used with above fiber adapters

SH to BNC adapter

Allows raw voltage output from thermal sensors

IR Phosphor Glass

1.1.4.3 High Power Water Cooled and Fan Cooled Laser Beam Dumps

Up to 10kW

Features

- Up to 10kW CW
- Water or Fan cooled
- High Power Density
- φ45-50mm aperture

BDFL500A-BB-50

BD5000W-BB-50

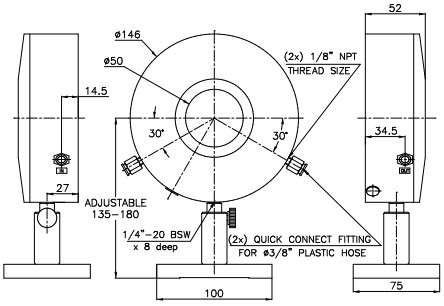
BD10K-W

Model	**BDFL500A-BB-50**	**BD5000W-BB-50**	**BD10K-W**
Use		**General purpose High power beam dump**	
Absorber Type	Broadband	Broadband	Beam Deflector + Broadband
Spectral Range µm	0.19 - 20	0.19 - 20	0.19 - 20
Typical Absorption		86% for 600 to 2500nm, 82% for 10.6µm	
Aperture mm	φ 50mm	φ 50mm	φ 45mm
Maximum Incident Power	500W	5000W	10,000W
Maximum Average Power Density	7kW/cm²	6kW/cm² at 1000W 3kW/cm² at 5000W	See note (b) below
Maximum Energy Density J/cm²			See note (b) below
<100ns	0.3		
1µs	0.4		
0.5ms	5		
2ms	10		
10ms	30		
Cooling	Fan	water	water
Minimum Water Flow Rate at Full Power	N/A	4.5 liter/min [a]	9 liter/min [a]
Weight kg	0.9	2.8	4.5
Version			
Part number	**7Z17200**	**7Z17201**	**7Z17202**
Notes: (a)	Water temperature range 18-30°C. Water temperature rate of change <1°C/min		

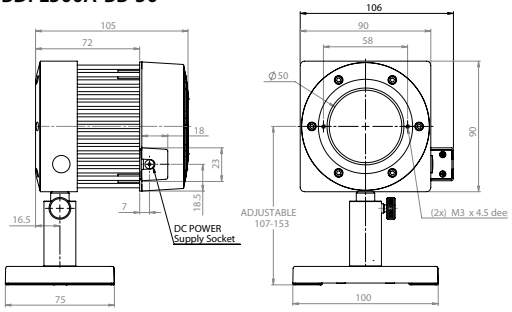
Notes: (b) Max power and energy density

Beam diameter	Max power density	Max energy density		
		1ms pulse width	3ms pulse width	10ms pulse width
<15mm	10kW/cm²	30J/cm²	60J/cm²	150J/cm²
15 - 20mm	7kW/cm²	20J/cm²	40J/cm²	100J/cm²
20 - 40mm	5kW/cm²	15J/cm²	30J/cm²	70J/cm²
40 - 45mm	4kW/cm²	12J/cm²	25J/cm²	60J/cm²

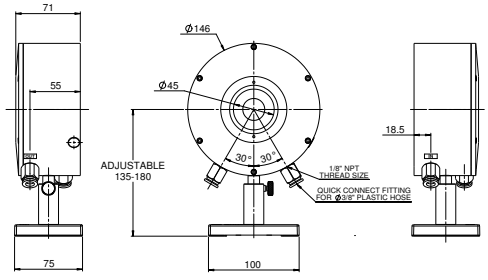
BD5000W-BB-50



BDFL500A-BB-50



BD10K-W



1.1.5 OEM Solutions

Introduction

Many laser systems manufacturers need to have a measuring capability built into their systems.
Ophir is the world's leading supplier of OEM laser power/energy measurement instrumentation which can be built into host systems (such as medical, industrial, etc). With extensive experience accumulated in the field, Ophir offers the largest variety of OEM products and is therefore best able to satisfy customer requirements.

Many configurations possible

An OEM solution is usually needed to monitor laser performance in the system, and possibly to provide fast feedback for system control. Depending on your application, various configurations can be used, such as:

- Simple sensor, with raw analog output
- Sensor with electronics providing an analog or digital output
- Complete instrument, including numeric display and/or PC interface
- Custom designed solution for special requirements

In the following pages, you will see a range of "standard" OEM sensors available; these are actually families of existing OEM sensors with typical specifications shown. They can be tailored as needed to fit your specific requirements.

In addition to the products described below, Ophir has developed hundreds of other OEM solutions. Simply contact your Ophir representative who is likely to have just the right solution to your needs.

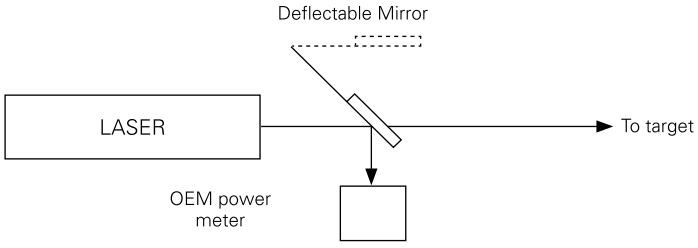
Thermal OEM Sensors

Ophir pioneered the compact self-contained laser power meter sensors with built-in amplifiers. These sensors are easy to install and give a calibrated voltage, proportional to power. They contain all the electronics needed including a speed up circuit to increase the speed of response of the sensor to the order of 1s, 0-95%. Connections to the sensors are simple, with the host providing DC power and the sensor providing a voltage output proportional to power.

In most cases, the sensor is used in one of three ways:

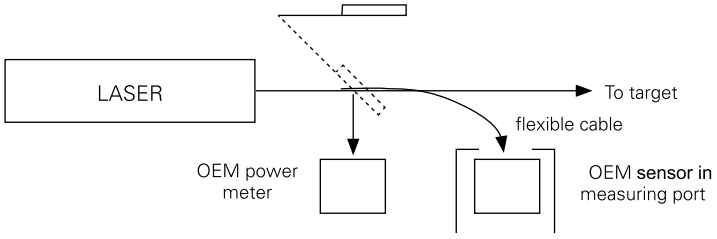
1. Beam Dump Mode

For lasers, such as surgical lasers, which are used in short bursts, the sensor is a beam dump with full power on it at all times except for the short periods of beam use when the beam is deflected to the work area.



2. Sampling Mode

In this mode, the laser is usually available to the user and is only deflected to the monitor for short times when the beam is sampled by the sensor. Sampling is performed with a deflection mirror or with an output fiber optic cable which is inserted into the measuring port from time to time.



3. Rear Leak Mode

In this mode, a small fraction (0.5-2%) of the laser beam "leaks" out of the rear mirror of the laser and is constantly monitored by the sensor.

Advantages of Ophir Thermal OEM Sensors

Compactness

Available in sizes down to 38x38x25mm or 48x48x15mm.

Versatility

Ophir offers OEM sensors for any type and wavelength of laser, for any power or configuration. Although the power measured usually ranges from 1-150 watts, the sensors can measure from tens of mW or mJ to Kilowatts or hundreds of Joules, and can be cooled with water, air or conduction. Ophir offers a large selection of standard OEM sensors at competitive prices and excellent delivery times. If required, the package, including the connectors, can be customized to customer specifications.

Reliability and accuracy

Ophir's measuring sensors use the reliable and accurate thermopile disc principle: the output is a low impedance voltage proportional to power. The thermopile disc samples the entire beam, making it more accurate than silicon detectors. The thermopile provides a faster response than thermoelectric types. Suitable absorbers which will not burn out or change reading with high power density lasers are available for any application.

Calibration

Ophir sensors can be factory calibrated at all required wavelengths.

In addition to the sensors described below, Ophir offers a number of other OEM sensors with larger aperture, diffusers in front, special absorbers, single sided amplifiers (± voltage and ground is not required, only + voltage and ground) and other special features. Ophir also offers an OEM version of the Nova power meter consisting of just circuit boards with no casing, as well as OEM sensors with RS232 or USB output instead of analog voltage.

Possible configurations of thermal OEM solutions include:

- Disc with raw analog output
- Disc with separate amplifier board
- Sensor with either raw or amplified analog output
- Sensor with RS232 interface
- Sensor with USB interface
- Complete solution including sensor and meter

1.1.5.1 Standard OEM Thermal Sensors

10mW to 20W

Features

- Conduction cooled
- Spectrally flat
- "A" version gives analog voltage calibrated to power
- "UA" version can give analog voltage output or digital RS232 output and can measure power or energy. Can also have multiple switchable ranges and/or multiple switchable wavelengths
- "UAU" version is similar to the UA version but operates via the USB terminal of the PC

20C-SH

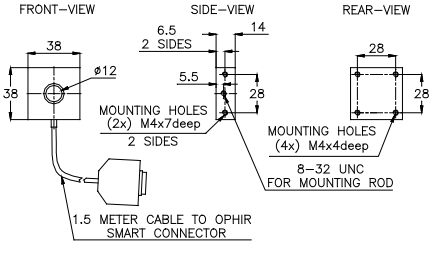
20C-A

20C-UAU

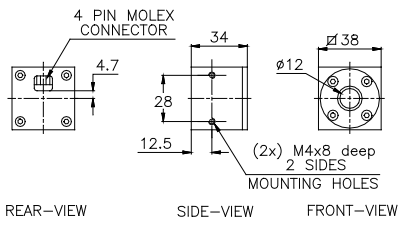
These specifications refer to standard OEM sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

Model	**20C-SH**	**20C-A**	**20C-UAU**
Type	**Smart sensor**	**Analog OEM sensor**	**Digital USB connection digital output**
Features	**Compact smart sensor**	**Compact, built in amplifier**	**Compact, external amplifier board**
Absorber Type	Broadband	Broadband	Broadband
Spectral Range µm	0.19 - 20	0.19 - 20 [c]	0.19 - 20 [c]
Aperture mm	φ12	φ12	φ12
Power Mode			
Maximum power [a]	4W free standing 20W heat sinked	4W free standing 20W heat sinked	4W free standing 20W heat sinked
Minimum power	10mW	20mW	10mW
Power Noise Level	0.2mW	0.5mW	0.2mW
Maximum Average Power Density kW/cm²	23 at 20W 35 at 4W	23 at 20W 35 at 4W	23 at 20W 35 at 4W
Response Time (0-95%), typ. (sec)	0.8	0.8	0.8
Power Accuracy +/-% at calibrated wavelength	3	3	3
Linearity with Power +/-%	1	1	1
Amplifier power supply (for A, UAU versions)	NA	±5V to ±18V regulated	Via host USB
Energy Mode			
Maximum Energy	10J	NA	NA
Minimum Energy	6mJ	NA	NA
Energy Accuracy +/-% at calibrated wavelength	5	NA	NA
Maximum Energy Density J/cm²			
<100ns	0.3	NA	NA
0.5ms	2	NA	NA
2ms	2	NA	NA
10ms	2	NA	NA
Cooling	conduction	conduction	conduction
Output	Ophir smart plug	4 pin Molex [b]	Mini B USB connector
Dimensions	38x38x14mm	38x38x34mm	38x38x14mm
Part number	**7Z02602**	**Consult Ophir representative**	**Consult Ophir representative**
Note: (a)	With analog "A" version, maximum power is also limited by maximum output voltage where output voltage is at most 2V less than input voltage.		
Note: (b)	4 pin Molex connections: +Voltage, -Voltage, Analog signal out, Ground		
Note: (c)	Calibrated at customer selected wavelength		

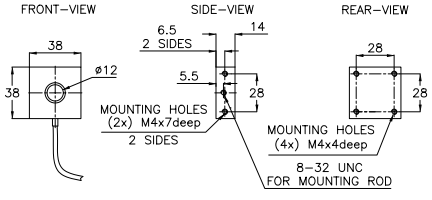
20C-SH



20C-A



20C-UAU



1.1.5.1 Standard OEM Thermal Sensors

80mW to 50W

Features

- Conduction cooled
- Spectrally flat
- "UA" version can give analog voltage output or digital RS232 output and can measure power or energy Can also have multiple switchable ranges and/or multiple switchable wavelengths
- "UAU" version is similar to the UA version but operates via the USB terminal of the PC

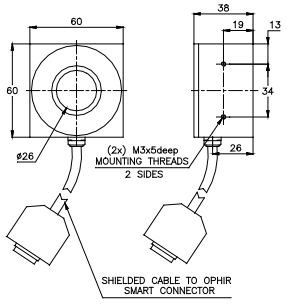
L30C-SH

L30C-UA

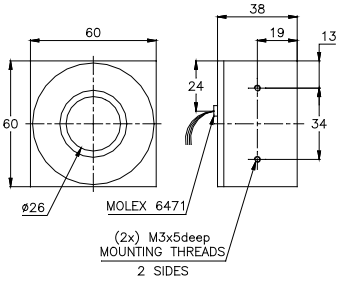
These specifications refer to standard OEM sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

Model	**L30C-SH**	**L30C-UA**	**L30C-UAU**
Type	**Smart sensor**	**Digital RS232 connection analog or digital output**	**Digital USB connection digital output**
Features	**Medium aperture smart sensor**	**Medium aperture, built in amplifier**	**Medium aperture, built in amplifier**
Absorber Type	Broadband	Broadband	Broadband
Spectral Range µm	0.19 - 20	0.19 - 20 (c)	0.19 - 20 (c)
Aperture mm	φ26	φ26	φ26
Power Mode			
Maximum power (a)	10W free standing 50W heat sinked	10W free standing 50W heat sinked	10W free standing 50W heat sinked
Minimum power	80mW	80mW	80mW
Power Noise Level	4mW	4mW	4mW
Maximum Average Power Density kW/cm²	17 at 50W 28 at 10W	17 at 50W 28 at 10W	17 at 50W 28 at 10W
Response Time (0-95%), typ. (sec)	1.5	1.5	1.5
Power Accuracy +/-% at calibrated wavelength	3	3	3
Linearity with Power +/-%	1	1	1
Amplifier power supply (for UA, UAU versions)	NA	±6V to ±24V	Via host USB
Energy Mode			
Maximum Energy	30J	100J	100J
Minimum Energy	30mJ	30mJ	30mJ
Energy Accuracy +/-% at calibrated wavelength	5	5	5
Maximum Energy Density J/cm²			
<100ns	0.3	0.3	0.3
0.5ms	5	5	5
2ms	10	10	10
10ms	30	30	30
Cooling	conduction	conduction	conduction
Output	Ophir smart plug	6 pin Molex (b)	Mini B USB connector
Dimensions	60x60x38mm	60x60x38mm	60x60x38mm
Part number	**773434**	**Consult Ophir representative**	**Consult Ophir representative**
Note: (a)	With analog "UA" version, maximum power is also limited by maximum output voltage where output voltage is at most 2V less than input voltage.		
Note: (b)	4 pin Molex connections: +Voltage, -Voltage, Analog signal out, Ground 6 pin Molex connections: RS232 input, Ground, +Voltage, Analog signal out, high/low voltage or switch input when used, RS232 output		
Note: (c)	Calibrated at customer selected wavelength		

L30C-SH



L30C-UA



1.1.5.1 Standard OEM Thermal Sensors

60mW to 100W

Features

- Conduction or water cooled
- Spectrally flat
- "UA" version can give analog voltage output or digital RS232 output and can measure power. Can also have multiple switchable ranges and/or multiple switchable wavelengths
- "UAU" version is similar to the UA version but operates via the USB terminal of the PC

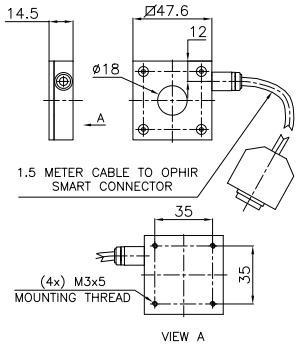
100C-SH

100C-UA/100C-UAU

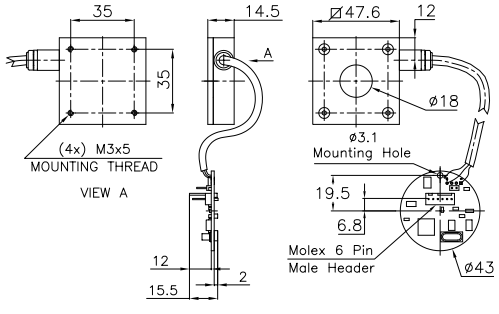
The following specifications refer to standard OEM sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

Model	**100C-SH**	**100C-UA**	**100C-UAU**
Type	**Smart sensor**	**Digital RS232 connection analog or digital output**	**Digital USB connection digital output**
Features	**Low profile, smart sensor**	**Low profile, separate amplifier**	**Low profile, separate amplifier**
Absorber Type	Broadband	Broadband	Broadband
Spectral Range µm	0.19 - 20	0.19 - 20 [c]	0.19 - 20 [c]
Aperture mm	φ 18	φ 18	φ 18
Power Mode			
Maximum power [a]	100W if used with suitable heat sink, 4W free standing	100W if used with suitable heat sink, 4W free standing	100W if used with suitable heat sink, 4W free standing
Minimum power	60mW	60mW	60mW
Power Noise Level	3mW	3mW	3mW
Maximum Average Power Density kW/cm²	30 at 4W 14 at 100W	30 at 4W 14 at 100W	30 at 4W 14 at 100W
Response Time (0-95%), typ. (sec)	1.2	1.2	1.2
Power Accuracy +/-% at calibration wavelength	3	3	3
Linearity with Power +/-%	1	1	1
Amplifier power supply (for UA, UAU versions)	NA	±6V to ±24V	Via host USB
Energy Mode (where applicable)			
Maximum Energy	NA	NA	NA
Minimum Energy	NA	NA	NA
Maximum Energy Density J/cm²			
<100ns	NA	NA	NA
0.5ms	NA	NA	NA
2ms	NA	NA	NA
10ms	NA	NA	NA
Cooling	conduction	conduction	conduction
Output	Ophir smart plug	6 pin Molex [b]	Mini B USB connector
Dimensions	48x48x14.5mm	48x48x14.5mm	48x48x14.5mm
Part number	**7Z02680**	**Consult Ophir representative**	**Consult Ophir representative**
Note: (a)	With analog "UA" version, maximum power is also limited by maximum output voltage where output voltage is at most 2V less than input voltage.		
Note: (b)	4 pin Molex connections: +Voltage, -Voltage, Analog signal out, Ground 6 pin Molex connections: RS232 input, Ground, +Voltage, Analog signal out, high/low voltage or switch input when used, RS232 output		
Note: (c)	Calibrated at customer selected wavelength		

100C-SH



100C-UA



1.1.5.1 Standard OEM Thermal Sensors

60mW to 150W

Features

- Conduction or water cooled
- Spectrally flat
- "UA" version can give analog voltage output or digital RS232 output and can measure power or energy. Can also have multiple switchable ranges and/or multiple switchable wavelengths
- "UAU" version is similar to the UA version but operates via the USB terminal of the PC

150C-SH

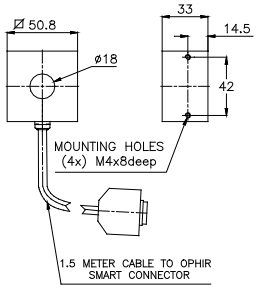
150C-UA/150C-UAU

150W-UA/150W-UAU

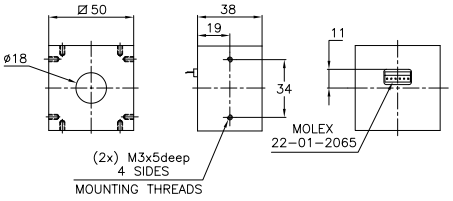
The following specifications refer to standard OEM sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

Model	**150C-SH**	**150C-UA**	**150W-UA**	**150C / W-UAU**
Type	**Smart sensor**	**Digital RS232 connection analog or digital output**	**Digital RS232 connection analog or digital output**	**Same as UA but with digital mini USB connection digital output only**
Features	**High power, smart sensor**	**High power, built-in amplifier**	**High power, built-in amplifier, water cooled**	
Absorber Type	Broadband	Broadband	Broadband	
Spectral Range µm	0.19 - 20	0.19 - 20 (c)	0.19 - 20 (c)	
Aperture mm	φ 18	φ 18	φ 18	
Power Mode				
Maximum power (a)	60W if used with suitable heat sink, 5W free standing	60W if used with suitable heat sink, 5W free standing	150W	
Minimum power	60mW	60mW	100mW	
Power Noise Level	3mW	3mW	5mW	
Maximum Average Power Density kW/cm²	30 at 5W 20 at 60W	30 at 5W 20 at 60W	12 at 150W	
Response Time (0-95%), typ. (sec)	1.2	1.2	1.2	
Power Accuracy +/-% at calibration wavelength	3	3	3	
Linearity with Power +/-%	1	1	1	
Amplifier power supply (for UA, UAU versions)	NA	±6V to ±24V	±6V to ±24V	Via host USB
Energy Mode (where applicable)				
Maximum Energy	100J	100J	100J	
Minimum Energy	20mJ	20mJ	50mJ	
Maximum Energy Density J/cm²				
<100ns	0.3	0.3	0.3	
0.5ms	5	5	5	
2ms	10	10	10	
10ms	30	30	30	
Cooling	Conduction	Conduction	Water	
Output	Ophir smart plug	6 pin Molex (b)	6 pin Molex (b)	Mini B USB connector
Dimensions	50.8x50.8x33mm	50x50x38mm	50x50x38mm	
Part number	**77023**	**Consult Ophir representative**	**Consult Ophir representative**	**Consult Ophir representative**
Note: (a)	With analog "UA" version, maximum power is also limited by maximum output voltage where output voltage is at most 2V less than input voltage.			
Note: (b)	4 pin Molex connections: +Voltage, -Voltage, Analog signal out, Ground 6 pin Molex connections: RS232 input, Ground, +Voltage, Analog signal out, high/low voltage or switch input when used, RS232 output			
Note: (c)	Calibrated at customer selected wavelength			

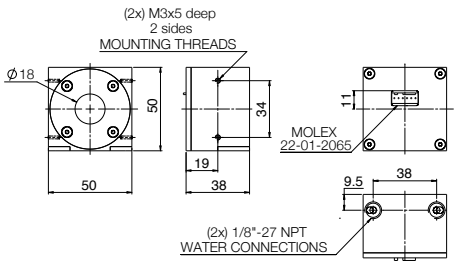
150C-SH



150C-UA



150W-UA



1.1.5.1 Standard OEM Thermal Sensors

0.2W to 300W

Features

- Conduction and water cooled
- Spectrally flat
- "UA" version can give analog voltage output or digital RS232 output and can measure power or energy. Can also have multiple switchable ranges and/or multiple switchable wavelengths
- "UAU" version is similar to the UA version but operates via the USB terminal of the PC

L150C-UA / L150C-UAU

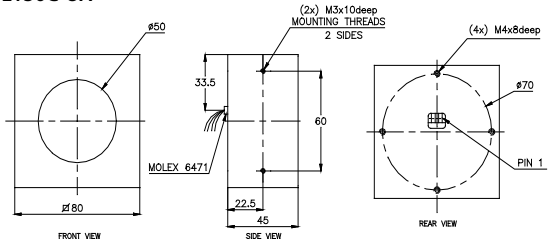
L250W-UA / L250W-UAU
L300W-UA / L300W-UAU

The following specifications refer to standard OEM sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

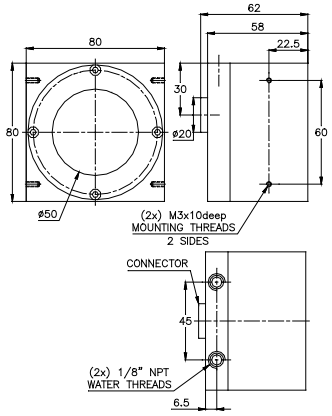
Model	**L150C-UA**	**L250W-UA**	**L300W-UA**	**L150C-UAU L250W-UAU L300W-UAU**
Type	**Digital RS232 connection analog or digital output**	**Digital RS232 connection analog or digital output**	**Digital RS232 connection analog or digital output**	**Same as UA but with digital mini USB connection digital output only**
Features	**Large aperture, built-in amplifier**	**Large aperture, built-in amplifier, water cooled**	**Large aperture, built-in amplifier, water cooled**	
Absorber Type	Broadband	Broadband	Broadband	
Spectral Range µm	0.19 - 20 (c)	0.19 - 20 (c)	0.19 - 20 (c)	
Aperture mm	φ 50	φ 50	φ 50	
Power Mode				
Maximum power (a)	20W free standing, 150W heat sinked	250W water cooled	300W water cooled	
Minimum power	0.2W	0.3W	0.5W	
Power Noise Level	10mW	15mW	25mW	
Maximum Average Power Density kW/cm²	27 at 20W 12 at 150W	10 at 250W	9 at 300W	
Response Time (0-95%), typ. (sec)	2.5	2.5	2.5	
Power Accuracy +/-% at calibration wavelength	3	3	3	
Linearity with Power +/-%	1	2	2	
Amplifier power supply (for UA, UAU versions)	±6V to ±24V	±6V to ±24V	±6V to ±24V	Via host USB
Energy Mode (where applicable)				
Maximum Energy	100J	200J	300J	
Minimum Energy	80mJ	120mJ	200mJ	
Maximum Energy Density J/cm²				
<100ns	0.3	0.3	0.3	
0.5ms	5	5	5	
2ms	10	10	10	
10ms	30	30	30	
Cooling	conduction	water	water	
Output	6 pin Molex (b)	6 pin Molex (b)	6 pin Molex (b)	Mini B USB connector
Dimensions	80x80x45mm	80x80x58mm	80x80x58mm	
Part number	**Consult Ophir representative**	**Consult Ophir representative**	**Consult Ophir representative**	**Consult Ophir representative**

Note: (a)	With analog "UA" version, maximum power is also limited by maximum output voltage where output voltage is at most 2V less than input voltage.
Note: (b)	4 pin Molex connections: +Voltage, -Voltage, Analog signal out, Ground 6 pin Molex connections: RS232 input, Ground, +Voltage, Analog signal out, high/low voltage or switch input when used, RS232 output
Note: (c)	Calibrated at customer selected wavelength

L150C-UA



L250W-UA / L300W-UA



1.1.5.2 Examples of Custom OEM Power Sensor Solutions

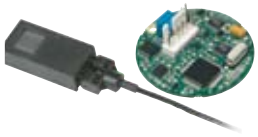
In addition to the standard OEM products described above, Ophir has accumulated over 25 years experience in developing products which are tailored to precise physical configurations provided by the OEM customer. These products include custom discs (with or without electronics), specially configured thermal- or photodiode-based power sensors, and much more. A number of these special OEM products are shown below.

OEM Photodiode Sensor with RS232 Output

This sensor is similar to the UA thermal OEM sensors described above, except it has a photodiode instead of thermal detector. The sensor shown has 5 decades of dynamic range and has the following dimensions: 50mm x 50mm x 33mm.

OEM Photodiode Sensor with Universal Amplifier Board

Truncated PD300 sensor with Universal amplifier board giving calibrated voltage output. Either analog or RS232 communication.



Flat Profile Thermal Sensor

This sensor with 50mm aperture is used as an exposure detector for photolithography and is only 10mm thick.

Super Compact Thermal Sensor

Thermal OEM sensor designed to be cemented into user system. Dimensions are under 10mm x 20mm footprint and 4mm height. The sensor can be connected to an Ophir smart meter to measure power or energy or can be used directly with voltage output.

Compact, hand held thermal Smart Sensor

This thermal sensor is only 20mm thick to enable probing in hard-to-reach locations, and can measure up to 25W. It is designed specifically to be hand-held, and works with any Ophir Smart Meter.

Ultra Fast OEM Power Sensor

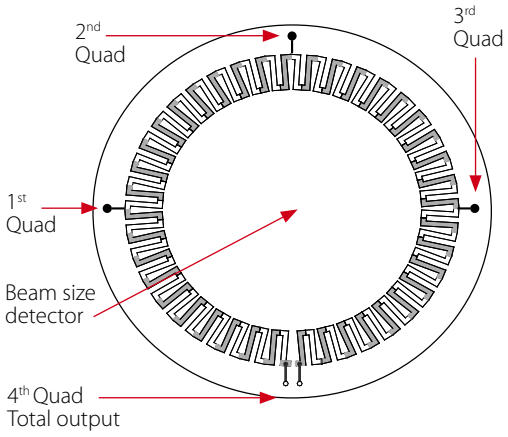
Using an innovative new axial thermopile method, this sensor is designed to be built into an industrial CO_2 or YAG laser for fast feedback to control the laser power stability.
It has a response time of 50ms and power capacity of 100W.

Ordering Information:

The products shown above are examples of OEM solutions developed for specific customer applications. Please consult with your Ophir representative who will be happy to help you with any requirements you may have.

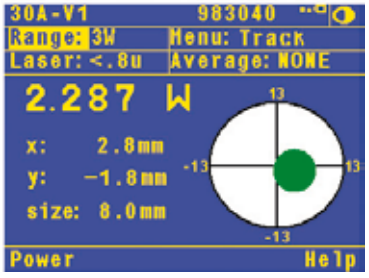
1.2 BeamTrack Power / Position / Size Sensors

Ophir now has the new BeamTrack line of thermal sensors that can measure beam position and beam size while measuring power. This innovative device will provide an additional wealth of information on your laser beam – centering, beam position, beam wander, beam position and wander, beam size as well as power and single shot energy. The BeamTrack sensor is illustrated schematically here and works as follows: the signal coming from the sensor is divided into 4 quadrants so by measuring and comparing the output from the 4 sections we can determine the position of the center of the beam to a high degree of accuracy. In addition to the 4 quadrants, there is now a special patented beam size detector. After processing outputs from these various detectors, the user is presented with the beam position as well as beam size. Note that the beam size is calibrated only for Gaussian beams but for other beams it will give relative size information and will indicate if the beam is changing size.



Operation of BeamTrack Sensors

BeamTrack sensors look similar to Ophir thermal sensors of the same type except that there is a small electronics module on the cable from the sensor head to the smart plug. When BeamTrack sensors are plugged into compatible displays or PC interfaces (Nova II, Vega, StarLite and Juno), along with the power measurement, there is a visual display of the beam position and beam size. The beam position can be accurately tracked and logged for beam wander measurements.



The beam size is calibrated only for Gaussian beams but other beams may be measured and the sensor will give a repeatable measurement of the relative beam size for tracking changes in the size of the beam over time.

1.2.1 BeamTrack-Power / Position / Size Sensors

100µW to 10W

Features

- All the features of standard power sensors plus...
- Accurate tracking of beam position to fractions of a mm
- Monitoring of the laser beam size

3A-QUAD / 3A-P-QUAD

10A-PPS

Model	3A-QUAD [a]	3A-P-QUAD [a]	10A-PPS [a]
Use	**General purpose**	**Short pulses**	**Low power**
Functions	Power / Energy / Position	Power / Energy / Position	Power / Energy / Position / Size
Absorber Type	Broadband	P type	Broadband
Spectral Range µm	0.19 - 20	0.15 - 8	0.19 - 20
Aperture mm	φ 9.5mm	φ 12mm	φ 16mm
Power Mode			
Power Range	100µW - 3W	160µW - 3W	20mW - 10W
Power Scales	3W to 300µW	3W to 300µW	10W / 5W / 0.5W
Power Noise Level	5µW	10µW	1mW
Thermal Drift (30min)%	10 - 40µW[b]	10 - 40 µW [b]	NA
Maximum Average Power Density kW/cm²	1	0.05	28
Response Time with Display (0-95%) typ. s	1.8	2.5	0.8
Power Accuracy +/-%	3	3	3
Linearity with Power +/-%	1	1	1
Energy Mode			
Energy Range	20µJ - 2J	30µJ - 2J	6mJ - 2J
Energy Scales	2J to 200µJ	2J to 200µJ	2J / 200mJ
Minimum Energy	20µJ	30µJ	6mJ
Maximum Energy Density J/cm²			
<100ns	0.3	1[e]	0.3
0.5ms	1	1[e]	2
2ms	2	1[e]	2
10ms	4	1[e]	2
Beam Tracking Mode			
Position			
Beam Position Accuracy mm [c]	0.15	0.15	0.1
Beam Position Resolution mm	0.02	0.02	0.02
Min Power for Position Measurement	300µW	400µW	50mW
Size [d]			
Size Accuracy mm	NA	NA	±(5%+50µm) for centered beam
Size Range mm (4σ beam diameter)	NA	NA	1.5 - 10
Min Power for Size Measurement	NA	NA	50mW
Cooling	convection	convection	convection
Weight kg	0.3	0.3	0.3
Fiber Adapter Available (see page 44)	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC
Part number: Standard Sensor	**7Z07934**	**7Z07935**	**7Z07904**
StarLink Sensor: Direct USB link to PC (p. 42)	**787203**		**787202**

Notes: (a) The BeamTrack features are supported by Nova II, Vega and StarLite meters , Juno interface and StarLab application.

Notes: (b) Depending on room airflow and temperature variations.

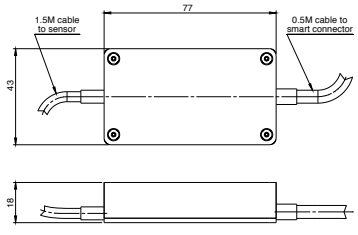
Notes: (c) For position within inner 30% of aperture.

Notes: (d) Assumes laser beam with Gaussian (TEM_{00}) distribution. For other modes, size measurement is relative.

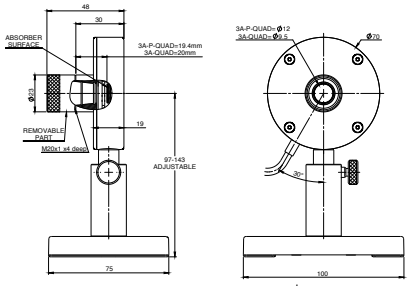
Notes: (e) For P type and shorter wavelengths derate maximum energy density as follows:

Wavelength	Derate to value
1064nm	not derated
532nm	not derated
355nm	40% of stated value
266nm	10% of stated value
193nm	10% of stated value

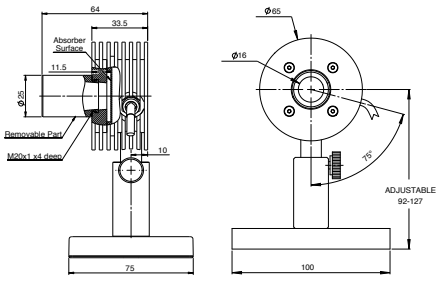
Interface Module on cable



3A-QUAD / 3A-P-QUAD



10A-PPS



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1.2.2 BeamTrack-Power / Position / Size Sensors

40mW to 150W

Features

- All the features of standard power sensors plus...
- Accurate tracking of beam position to fractions of a mm
- Monitoring of the laser beam size

50(150)A-BB-26-PPS

F150A-BB-26-PPS

Model	50(150)A-BB-26-PPS [a]	F150A-BB-26-PPS [a]
Use	**General purpose**	**General purpose**
Absorber Type	Broadband	Broadband
Spectral Range µm	0.19 - 20	0.19 - 20
Aperture mm	φ 26mm	φ 26mm
Power Mode		
Power Range	40mW - 150W	50mW - 150W [b]
Maximum Intermittent Power	150W for 1.5min, 100W for 2.2min, 50W continuous	NA
Power Scales	150W / 50W / 5W	150W / 30W / 3W
Power Noise Level	2mW	8mW [b]
Maximum Average Power Density kW/cm²	12 at 150W, 17 at 50W	12 at 150W, 17 at 50W
Response Time with Display (0-95%) typ. s	1.5	1.5
Power Accuracy +/-%	3	3
Linearity with Power +/-%	1.5	1
Energy Mode		
Energy Range	20mJ - 100J	20mJ - 100J
Energy Scales	100J / 30J / 3J / 300mJ	100J / 30J / 3J / 300mJ
Minimum Energy mJ	20	20 [b]
Maximum Energy Density J/cm²		
<100ns	0.3	0.3
0.5ms	5	5
2ms	10	10
10ms	30	30
Beam Tracking Mode		
Position		
Beam Position Accuracy mm [c]	0.1	0.1
Beam Position Resolution mm	2.5% of beam size	2.5% of beam size
Min Power for Position Measurement	100mW	100mW
Size [d]		
Size Accuracy mm [e]	±5% for centered beam	±5% for centered beam
Size Range mm (4σ beam diameter)	φ3 - 20	φ3 - 20
Min Power Density for Size Measurement	1 W/cm²	1 W/cm²
Cooling	convection	fan
Fiber Adapter Available (see page 44)	ST, FC, SMA, SC	ST, FC, SMA, SC
Weight Kg	0.4	0.45
Version		
Part number: Standard Sensor	**7Z07900**	**7Z07901**
StarLink Sensor: Direct USB link to PC (p. 42)	**787200**	

Notes: (a) The BeamTrack features are supported by Nova II, Vega and StarLite meters , Juno interface and StarLab application.

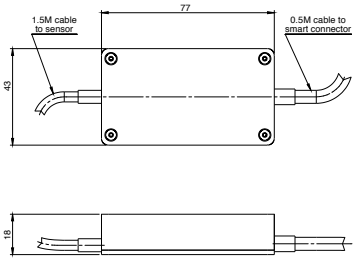
Notes: (b) For powers up to 30W it is recommended to work with the fan off and then the noise level is ~3 times lower. It is also recommended to measure energy with the fan off.

Notes: (c) Position accuracy for the central 10mm of the aperture as limited by beam position resolution. Position can be tracked with ±1mm accuracy over the entire aperture. Accuracy is reduced by a factor of 3 at minimum power.

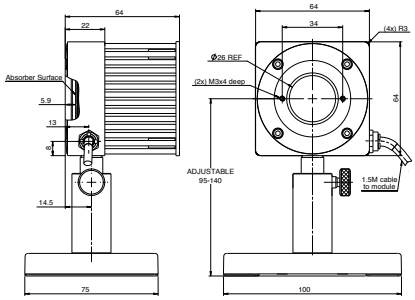
Notes: (d) Assumes laser beam with Gaussian (TEM_{00}) distribution. For other modes, size measurement is relative.

Notes: (e) Accuracy spec will be maintained for beams from 3.5 to 17mm not deviating from center more than 15% of beam diameter. For beams below 8mm in size and powers above 75W error in size can reach ±10%.

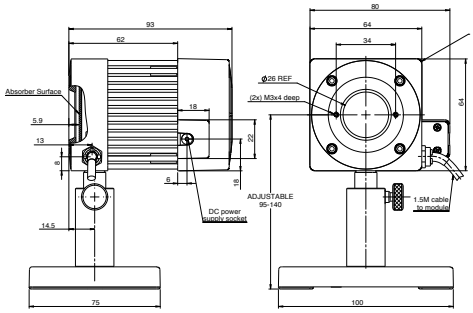
Interface Module on cable



50(150)A-BB-26-PPS



F150A-BB-26-PPS



1.2.3 BeamTrack-Power / Position / Size Sensors

150mW to 250W

Features

- All the features of standard power sensors plus...
- Accurate tracking of beam position to fractions of a mm
- Monitoring of the laser beam size

FL250A-BB-50-PPS

Model	**FL250A-BB-50-PPS** [a]
Use	**General purpose**
Absorber Type	Broadband
Spectral Range µm	0.19 - 20
Aperture mm	φ 50mm
Power Mode	
Power Range [b]	150mW - 250W
Power Scales	250W / 30W
Power Noise Level	15mW
Maximum Average Power Density kW/cm²	10 at 250W, 12 at 150W
Response Time with Display (0-95%) typ. s	2.8
Power Accuracy +/-%	3
Linearity with Power +/-%	1.5
Energy Mode	
Energy Range	80mJ - 300J
Energy Scales	300J / 30J / 3J
Minimum Energy mJ	80
Maximum Energy Density J/cm²	
<100ns	0.3
0.5ms	5
2ms	10
10ms	30
Beam Tracking Mode	
Position	
Beam Position Accuracy mm [c]	0.2
Beam Position Resolution mm	0.1
Min Power for Position Measurement	2W
Size [d]	
Size Accuracy mm [e]	±5% for centered beam
Size Range mm (4σ beam diameter)	Ø 5-35
Min Power Density for Size Measurement	3 W/cm²
Cooling	fan
Fiber Adapter Available (see page 44)	ST, FC, SMA, SC
Weight Kg	0.9
Version	
Part number: Standard Sensor	**7Z07902**
StarLink Sensor: Direct USB link to PC (p. 42)	**787201**

Notes: (a) The BeamTrack features are supported by Nova II, Vega and StarLite meters, Juno interface and StarLab application.

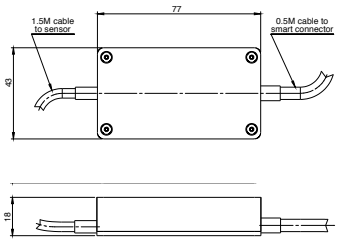
Notes: (b) For powers up to 50W it is recommended to work with the fan off and then the noise level is ~3 times lower. It is also recommended to measure energy with the fan off.

Notes: (c) Position accuracy for the central 20mm of the aperture as limited by beam position resolution. Position can be tracked with ±1mm accuracy over central 32mm of the aperture. Accuracy is reduced by a factor of 3 at minimum power.

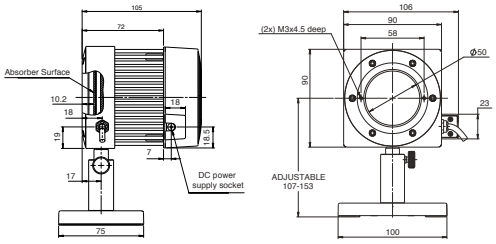
Notes: (d) Assumes laser beam with Gaussian (TEM_{00}) distribution. For other modes, size measurement is relative.

Notes: (e) Accuracy spec will be maintained for beams from 6 to 35mm not deviating from center more than 15% of beam diameter.

Interface Module on cable



FL250A-BB-50-PPS

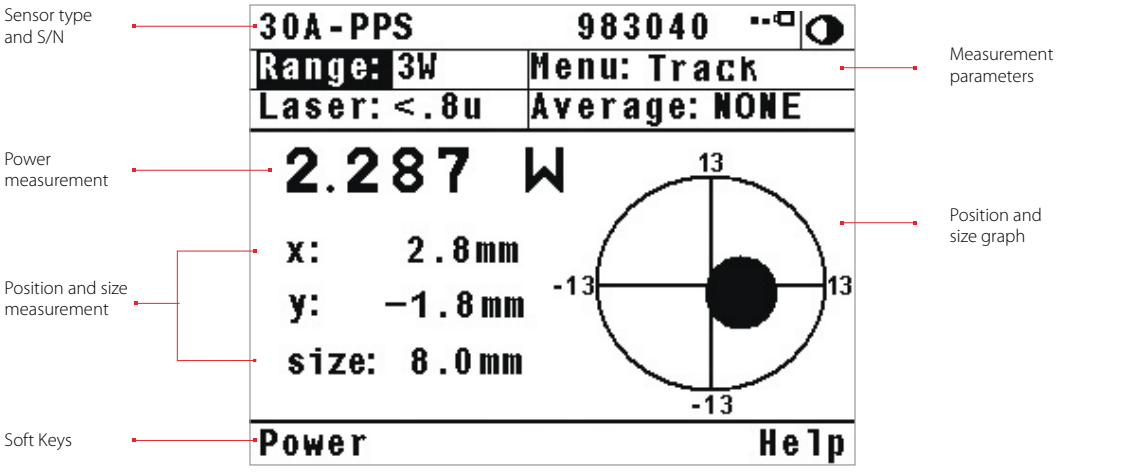


1.2.4 BeamTrack-Power / Position / Size Sensors

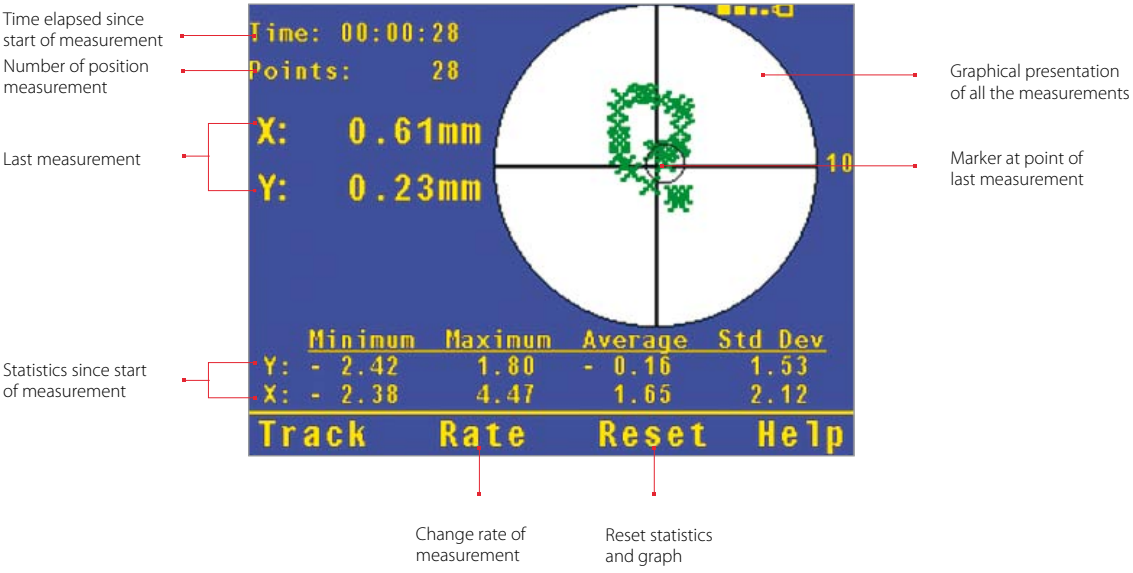
Device Software Support

- BeamTrack sensors are fully supported by the Vega, Nova-II, StarLite and Juno devices
- Attach the sensor to the meter. On startup, it will be recognized as a BeamTrack sensor and tracking options will be enabled
- Use the Track screen to measure power, position and size simultaneously
- Use the Stability screen to measure pointing stability (also known as beam wander) over time

Track Screen on Nova II



Pointing Stability Screen of Vega


Time elapsed since start of measurement
Time: 00:00:28
Number of position measurement
Points: 28
Last measurement
X: 0.61mm
Y: 0.23mm
Graphical presentation of all the measurements
10
Marker at point of last measurement
Minimum Maximum Average Std Dev
Statistics since start of measurement
Y: - 2.42 1.80 - 0.16 1.53
X: - 2.38 4.47 1.65 2.12
Track Rate Reset Help
Change rate of measurement
Reset statistics and graph

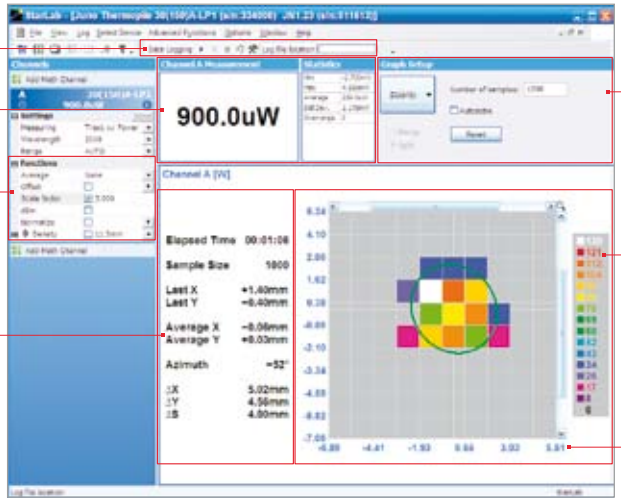
1.2.4 BeamTrack-Power / Position / Size Sensors

PC Software Support

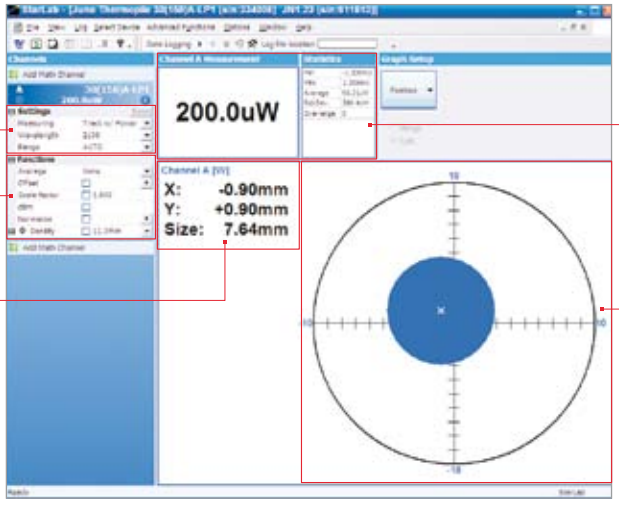
- StarLab
- COM Object for System Integrators including demo applications in VB, VC+ and MatLab
  the Track screen to measure power, position and size simultaneously
- LabVIEW Demo Application

Examples of some StarLab Screens

Stability Screen


Log data for future review
Power measurement and statistics
Functions (apply to power only)
Statistics of the stability sample
900.0uW
Graph controls including; Sample size, Autoscale option, Reset button and Graph type selections
Stability Graph. The more hits in one location the brighter the color
Graph can be zoomed in and out manually or auto-scaled

Position & SizeScreen



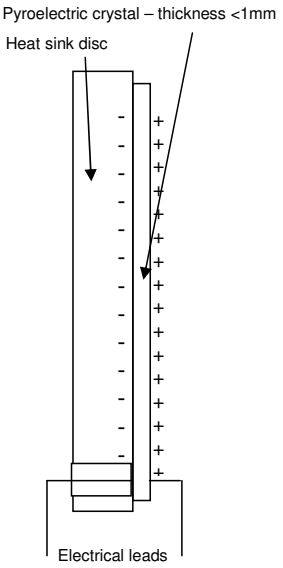
Energy sensors

Energy Sensors

Introduction

Ophir has two types of energy sensors, pyroelectric and RP. Pyroelectric sensors are for measuring repetitive pulse energies and average powers at pulse rates up to 25000 pulses per second and pulse widths up to 20ms. RP sensors are specialty items mainly for very long pulse widths and very high average powers that cannot be measured by pyroelectric sensors. Note that single shot energy with pulse rates less than one pulse every 5s or so can be measured with thermal sensors described in the power sensor section.

Pyroelectric Sensors



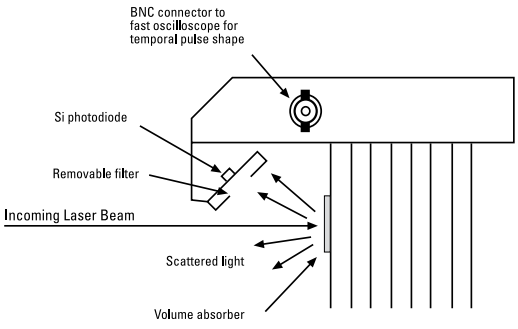
Pyroelectric type sensors are useful for measuring the energy of repetitively pulsed lasers at up to 25,000Hz and are sensitive to low energies.
They are less durable than thermal types and therefore should not be used whenever it is not necessary to measure the energy of each pulse and average power measurement is sufficient.
Pyroelectric sensors use a pyroelectric crystal that generates an electric charge proportional to the heat absorbed. Since the two surfaces of the crystal are metalized, the total charge generated is collected and therefore the response is not dependent on beam size or position. This charge then charges a capacitor in parallel with the crystal and the voltage difference thus generated is proportional to the pulse energy. After the energy is read by the electronic circuit, the charge on the crystal is discharged to be ready for the next pulse. The response time of the pyroelectric sensor depends on the time it takes for the heat to enter the crystal and heat it up. For metallic type pyro detectors, this time is tens of µs and thus the metallic type can run at a high repetition rate. For the BF and BB type, the response time is hundreds of µs with a correspondingly lower repetition rate.
Ophir pyroelectric detectors have unique and proprietary circuitry that allow them to measure long pulses as well as short pulses and work at a high duty cycle, i.e. where the pulse width is as much as 30% of the total cycle time.
Ophir came out with the new compact C line of pyroelectric sensors that replaced previous models. The electronics and mechanics has been completely upgraded and the new sensors are superior in every way: more compact, wider dynamic range, have higher repetition rates and measure longer pulses. Through constant development, Ophir again brings you the best performance in the market.

RP Sensors

The exclusive Ophir RP type heads represent a unique way of accurately measuring the energy of high average power and large duty cycle pulsed lasers, while at the same time measuring average power and temporal pulse shape.

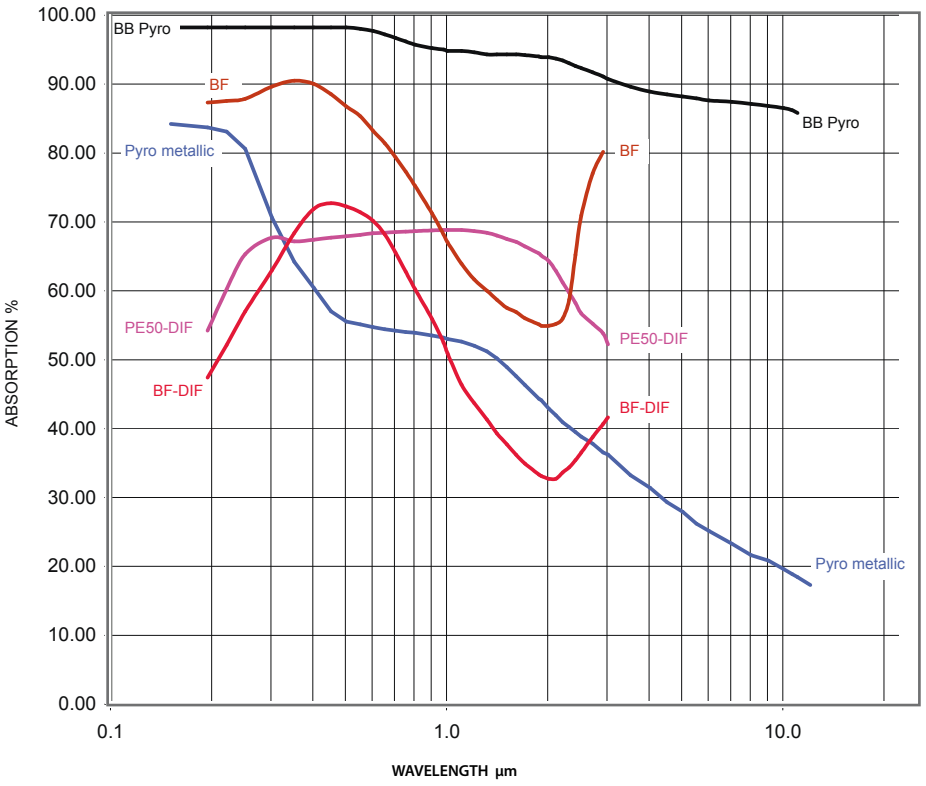
Principle of Operation

RP heads incorporate an innovation (patented) that allows measurement of the energy of high energy repetitively pulsed lasers which is of advantages over pyroelectric measurement in certain cases: higher average powers than a pyroelectric and high duty cycles up to 70% which are typical of switched diode lasers.
The basic approach is to incorporate two sensors in one measurement head. The RP measurement head has a standard thermopile type detector enabling it to measure average laser power to a high degree of accuracy, generally ±3%. In addition, it contains a fast photodiode detector, which measures the energy of the laser pulses in real time. The photodiode detector is mounted so that a fraction of the radiation falling on the thermopile absorber, 4% to 15% depending on head type, is scattered from the absorber. A fraction of that falls on the photodiode, see illustration below (there is also a larger, fast photodiode connected directly to an oscilloscope via the BNC connector enabling it to measure the temporal pulse shape of the beam to a resolution of ns). Combining the average power measurement with the relative pulse energy and repetition rate, the unit calculates the absolute energy per pulse.

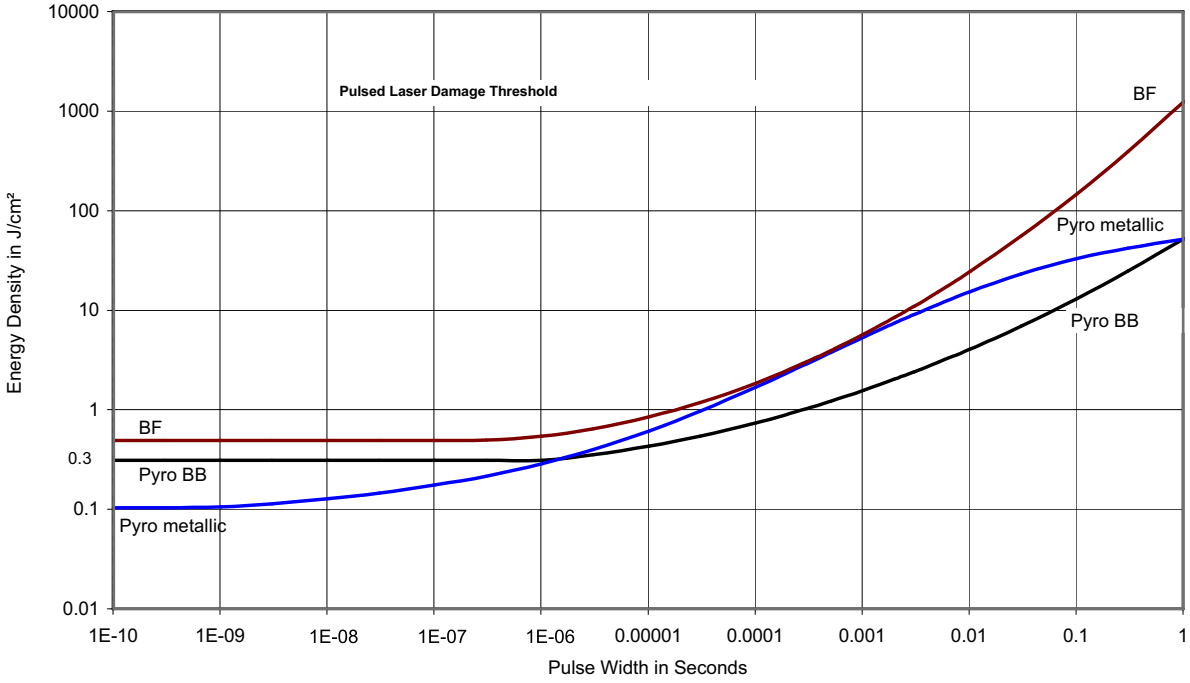


Absorption and Damage Graphs for Pyroelectric Sensors

Absorption vs. Wavelength

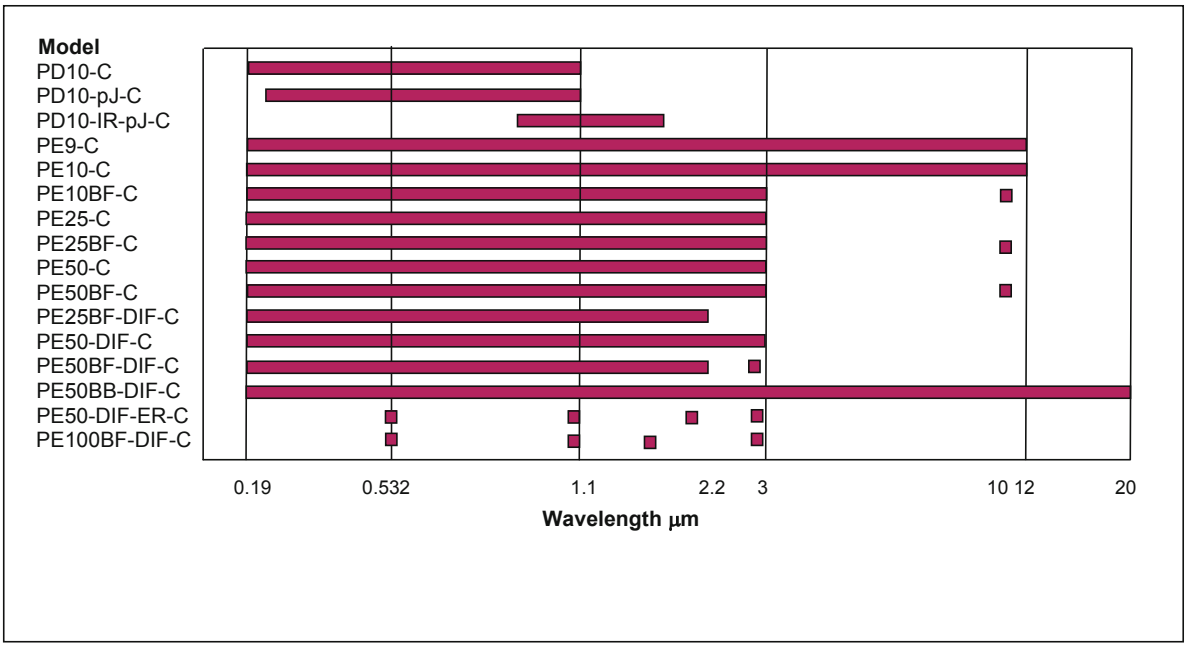


Damage Threshold vs. Pulse Width

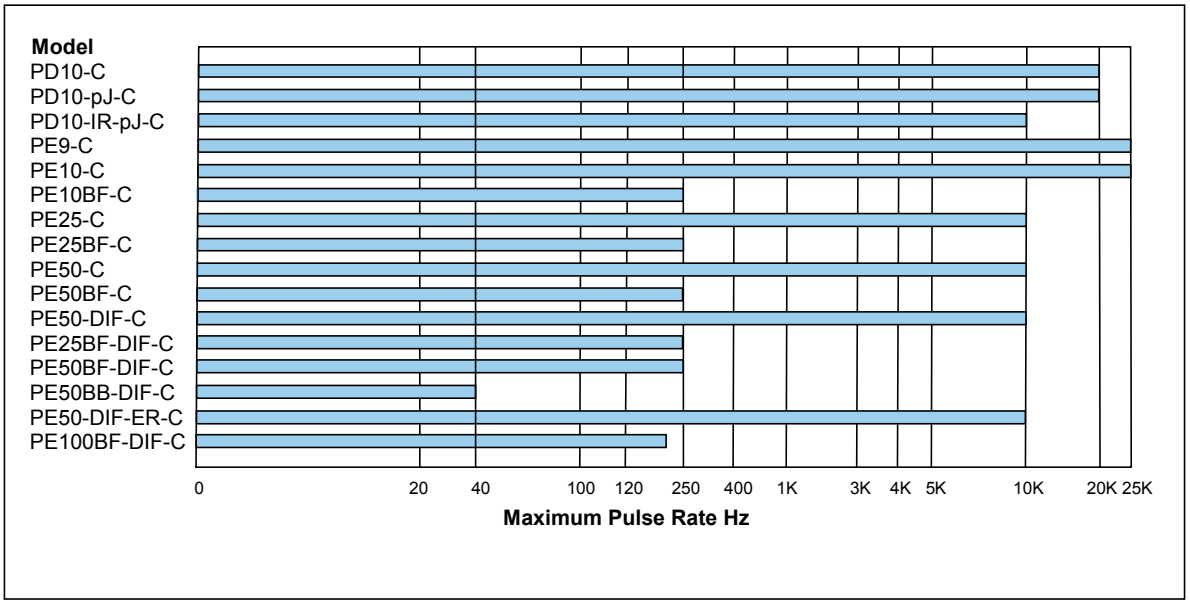


Wavelength Range and Repetition Rate for Energy Sensors

Wavelength Range



Repetition Rate Range



1.3.1 Photodiode Energy Sensors

10pJ to 15µJ

Features

- Silicon and Germanium detectors
- Very sensitive - down to 10pJ
- Repetition rates to 20kHz
- Wide spectral range

PD10-C / PD10-pJ-C / PD10-IR-pJ-C

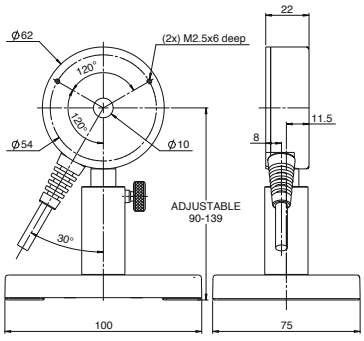
Model	PD10-C	PD10-pJ-C	PD10-IR-pJ-C
Use	**Low energies**	**Lowest energies**	**Infrared**
Aperture mm	φ10	φ10	φ 5
Absorber Type	Si photodiode with attenuator	Si photodiode	Ge photodiode
Spectral Range µm [a]	0.19 - 1.1	0.2 - 1.1	0.7 - 1.8
Surface Reflectivity % approx.	50	30	30
Calibration Accuracy +/-% [a]	5	5	5
Energy Scales	20µJ to 20nJ	200nJ to 200pJ	20nJ to 200pJ
Lowest Measurable Energy nJ [b]	1 at 900nm	0.01 at 900nm	0.03 at 1550nm
Max Pulse Width ms	0.005	0.005	0.005
Maximum Pulse Rate pps	20kHz	20kHz	10kHz
Noise on Lowest Range nJ	0.05	0.001	0.01
Additional Error with Frequency %	±1% to 20kHz [c]	±1% to 20kHz [d]	±1.5% to 10kHz
Linearity with Energy for > 10% of full scale [b]	±1.5%	±1.5%	±1.5%
Damage Threshold J/cm²	0.1	0.1	0.1
Maximum Average Power mW	50 at 800nm	0.5	0.5
Maximum Average Power Density W/cm²	50	5	5
Maximum Energy vs. Wavelength	Wavelength / Maximum Energy	Wavelength / Maximum Energy	Wavelength / Maximum Energy
	<300nm 15µJ	<300nm 150nJ	800 - 900nm 20nJ
	350-550nm 8µJ	350-550nm 75nJ	1000 - 1300nm 8nJ
	>800nm 5µJ	>800nm 50nJ	1300 - 1400nm 7nJ
			1480 - 1560nm 6nJ
			>1650nm 20nJ
Fiber Adapters Available (see page 76)	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC
Weight kg	0.25	0.25	0.25
Version			
Part number: Standard Sensor	**7Z02944**	**7Z02945**	**7Z02946**
Previous Model Part Number	**7Z02823**	**7Z02824**	**7Z02827**
Note: (a) This is basic calibration accuracy. In certain wavelength regions calibration there is additional error as tabulated here.	<250nm add ±3% >950nm add ±2%	<250nm add ±2% >950nm add ±2%	<900nm add ±2% >1700nm add ±2%

Note: (b) With the "user threshold" setting set to minimum. For other settings, the spec is for >10% of full scale or greater than twice the "user threshold", whichever is greater. The user threshold is available with Nova II, Vega, StarLite or Juno. For other meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PD-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 77). The adapter can introduce up to 1% additional measurement error.
The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments. For highest accuracy, it is recommended to zero the sensor against the meter the first time it is used with a particular meter. For further information, see the FAQs on our Website.

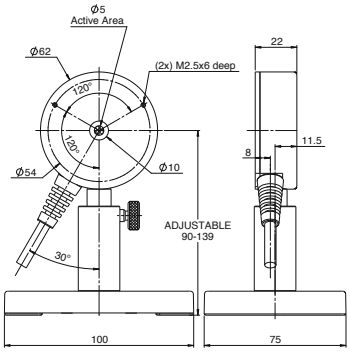
Note: (c) Additional Error with Frequency of ±1% on ly for energies up to 2µJ. For higher energies ±1% up to 10kHz, -4% at 20kHz.

Note: (d) Additional Error with Frequency of ±1% only for energies up to 20nJ. For higher energies ±2% up to 10kHz, -5% at 20kHz.

PD10-C / PD10-pJ-C



PD10-IR-pJ-C



1.3.2 Pyroelectric Energy Sensors

0.2µJ to 10mJ

Features

- φ8mm and φ12mm apertures
- Repetition rates up to 25,000Hz
- Highest sensitivity sensors
- Pulse widths up to 5ms
- New compact PE-C series

PE9-C

PE10-C / PE10BF-C

Model	PE9-C			PE10-C		PE10BF-C	
Use	**Most sensitive**			**Sensitive**		**High damage threshold**	
Aperture mm	φ8			φ12		φ12	
Absorber Type	metallic			metallic		BF	
Spectral Range µm [a]	0.15 - 12			0.15 - 12		0.15 - 3, 10.6 [e]	
Surface Reflectivity % approx.	50			50		20	
Calibration Accuracy +/-% [a]	3			3		3 [f]	
Max Pulse Width Setting [g]	1µs	2µs	20µs	1µs	30µs	1ms	5ms
Energy Scales	1mJ to 2µJ	1mJ to 2µJ	1mJ to 20µJ	10mJ to 2µJ	10mJ to 20µJ	10mJ to 20µJ	10mJ to 200µJ
Lowest Measurable Energy µJ [c, d]	0.5	<0.2	0.5	1	1	7	20
Max Pulse Width µs	1	2	20	1	30	1000	5000
Maximum Pulse Rate pps	25kHz	15kHz	10kHz	25kHz	5kHz	250Hz	50Hz
Noise on Lowest Range µJ	0.04	0.05	0.1	0.1	0.15	1	5
Additional Error with Frequency %	±1% to 15kHz, ±6% to 25kHz	±1% to 15kHz	±1% to 10kHz	±2% to 15kHz, ±3% to 25kHz	±1% to 5kHz	±1%	±1%
Damage Threshold J/cm²							
<100ns	0.1			0.1		0.8 [b]	
1µs	0.2			0.2		1 [b]	
300µs	3			3		2 [b]	
Linearity with Energy [c]	±1%			±1.5%		±2%	
Maximum Average Power W	2			2		3	
Maximum Average Power Density W/cm²	30			50		50	
Fiber Adapters Available (see page 76)	ST, FC, SMA, SC			ST, FC, SMA, SC		ST, FC, SMA, SC	
Weight kg	0.25			0.25		0.25	
Version							
Part Number: Standard Sensor	**7Z02933**			**7Z02932**		**7Z02938**	
Previous Model Part Number	PE-9: 7Z02877 PE9-F: 7Z02882						
StarLink Sensor: Direct USB link to PC (p. 75)				**787152**			
Note: (a) Calibrated curve is checked and adjusted at the following wavelengths (µm)	0.193, 0.355, 1.064, 1.48-1.6			0.193, 1.064, 0.355		0.193, 0.248, 0.355, 0.532, 1.064	
For other wavelengths in the curve there is additional calibration error as stated.	240 - 800nm add ±4%, 2-3µm add ±8%, 10.6µm add ±15%					0.2-3µm ±2%, 10.6µm ±5%	

Note: (b) For wavelenghts below 600nm, derate damage threshold to 60% of given values. Below 300nm, derate to 40% of given values.

Note: (c) For >7% of full scale, with the "user threshold" setting set to minimum. For other settings, the spec is for >7% of full scale or greater than twice the "user threshold", whichever is greater. The user threshold is available with Nova II, Vega, StarLite or Juno. For other meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PE-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 77). The adapter can introduce up to 1% additional measurement error.
The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments. The user threshold setting represents the approximate minimum energy for pulse widths below ~50% of the pulse width setting. For longer pulse widths, the actual minimum may be higher. For highest accuracy, it is recommended to zero the sensor against the meter the first time it is used with a particular meter. For further information, see the FAQs on our Website.

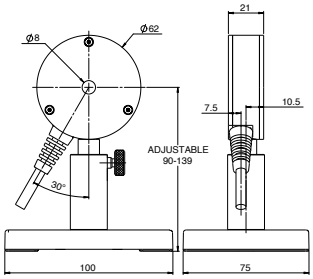
Note: (d) A shock absorbing mounting post is available for situations in which sensor is mounted on a surface subject to shock or vibration. This can prevent false triggering and allow working at lower minimum energies (see accessory page 77 for mounting post).

Note: (e) The 3000nm setting is calibrated for 10.6µm as well. To measure CO_2 laser, set to the 3000nm setting. The additional error for measuring 10.6µm is ±5%.

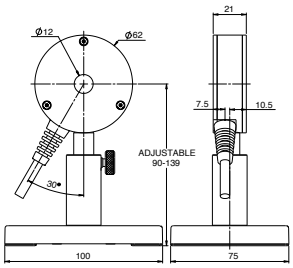
Note: (f) Add 3% to error for wavelengths >2µm.

Note: (g) For PE9-C: with the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter only 2 of the 3 pulse width settings are available; the 1µs and 2µs settings.

PE9-C



PE10-C / PE10BF-C



1.3.2 Pyroelectric Energy Sensors

8µJ to 10J

Features

- φ24mm apertures
- Metallic coating for high rep rates
- BF coating for highest damage threshold
- Rep rates up to 10kHz
- Measure lasers with pulse widths up to 20ms
- New compact PE-C series

PE25-C

PE25BF-C

Energy Sensor with optional heat sink

Model	**PE25-C**					**PE25BF-C**				
Use	**High rep rate**					**High damage threshold**				
Aperture mm	φ24					φ24				
Absorber Type	metallic					BF				
Spectral Range µm [a]	0.15 - 3					0.15 - 3, 10.6 [f]				
Surface Reflectivity % approx.	50					20				
Calibration Accuracy +/-% [a]	3					3				
Max Pulse Width Setting [e]	2µs	30µs	500µs	1ms	5ms	1ms	2ms	5ms	10ms	20ms
Energy Scales	10J to 200µJ	10J to 200µJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 2mJ
Lowest Measurable Energy µJ [c,d]	8	10	60	80	100	60	100	120	120	200
Max Pulse Width ms	0.002	0.03	0.5	1	5	1	2	5	10	20
Maximum Pulse Rate pps	10kHz	5kHz	900Hz	450Hz	100Hz	250Hz	100Hz	50Hz	40Hz	20Hz
Noise on Lowest Range µJ	0.5	1	6	10	20	10	20	20	20	40
Additional Error with Frequency %	±2% to 5kHz ±4% to 10kHz	±1.5%	±2% to 750Hz	±1.5% to 400Hz	±1.5% to 80Hz	±1%	±1%	±1%	±1%	±2%
Linearity with Energy for >7% of full scale [c]	±1.5%					±2%				
Damage Threshold J/cm² [b]										
<100ns	0.1					0.8				
1µs	0.2					1				
300µs	2					5				
2ms	6					10				
Maximum Average Power W [d]	15, 25 with optional heat sink					15, 25 with optional heat sink				
Maximum Average Power Density W/cm²	20					20				
Uniformity over surface	±2% over central 50% of aperture					±2% over central 50% of aperture				
Fiber Adapters Available (see page 76)	ST, FC, SMA, SC					ST, FC, SMA, SC				
Weight kg	0.25					0.25				
Version										
Part Number: Standard Sensor	**7Z02937**					**7Z02935**				
StarLink Sensor: Direct USB link to PC (p. 75)	**787156**					**787154**				
Note: (a) Calibration curve is verified and adjusted at specified wavelengths.	Specified wavelengths: 248-266nm, 355nm, 1064nm and 2940nm.					Specified wavelengths: 193nm, 248-266nm, 355nm, 532nm, 1064nm and 2940nm.				
At other wavelengths, there may be an additional error up to the value given.	Max additional error at other wavelengths: ±2%.					Max additional error at other wavelengths: ±2%.				
Note: (b)						For wavelengths below 600nm, derate damage threshold to 60% of given values. Below 300nm, derate to 40% of given values.				

Note: (c) With the "user threshold" setting set to minimum. For other settings, the spec is for >7% of full scale or greater than twice the "user threshold", whichever is greater.
The user threshold is available with Nova II, Vega, StarLite or Juno. For other meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PE-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 77). The adapter can introduce up to 1% additional measurement error.
The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments. The user threshold setting represents the approximate minimum energy for pulse widths below ~50% of the pulse width setting. For longer pulse widths, the actual minimum may be higher. For highest accuracy, it is recommended to zero the sensor against the meter the first time it is used with a particular meter. For further information, see the FAQs on our Website.

Note: (d) A shock absorbing mounting post is available for situations in which sensor is mounted on a surface subject to shock or vibration. This can prevent false triggering and allow working at lower minimum energies. Note however, that in this case the maximum average power will be reduced to 10W without heat sink and 20W with heat sink (see accessory pages 76-77 for heat sink and mounting post).

Note: (e) With the Laserstar, Pulsar, USBI Quasar and Nova or Orion with adapter only 2 of the 5 pulse width settings are available. For the PE-C models the 30µs and 1ms settings and for the PE-BF models the 1ms and 10ms settings.

Note: (f) The 3000nm setting is calibrated for 10.6µm as well. To measure CO_2 laser, set to the 3000nm setting. The additional error for measuring 10.6µm is ±5%.

* For sensors drawings please see page 71

1.3.2 Pyroelectric Energy Sensors

10µJ to 10J

Features

- φ46mm apertures
- Metallic coating for high rep rates
- BF coating for highest damage threshold
- Rep rates up to 10kHz
- Measure lasers with pulse widths up to 20ms
- New compact PE-C series

PE50-C

PE50BF-C

Energy Sensor with optional heat sink

Model	**PE50-C**					**PE50BF-C**				
Use	**High rep rate**					**High damage threshold**				
Aperture mm	φ46					φ46				
Absorber Type	metallic					BF				
Spectral Range µm [a]	0.15 - 3					0.15 - 3, 10.6 [f]				
Surface Reflectivity % approx.	50					20				
Calibration Accuracy +/-% [a]	3					3				
Max Pulse Width Setting [e]	2µs	30µs	500µs	1ms	5ms	1ms	2ms	5ms	10ms	20ms
Energy Scales	10J to 200µJ	10J to 200µJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 20mJ	10J to 20mJ	10J to 20mJ
Lowest Measurable Energy µJ [c,d]	10	10	60	80	100	120	300	600	600	600
Max Pulse Width ms	0.002	0.03	0.5	1	5	1	2	5	10	20
Maximum Pulse Rate pps	10kHz	5kHz	900Hz	450Hz	100Hz	250Hz	100Hz	50Hz	40Hz	20Hz
Noise on Lowest Range µJ	0.5	1	6	10	20	30	60	100	100	100
Additional Error with Frequency %	±2% to 2kHz ±4.5% to 5kHz	±2%	±2% to 750Hz	±2% to 400Hz	±1% to 80Hz	±1%	±1%	±1%	±1%	±2%
Linearity with Energy for >7% of full scale [c]	±1.5%					±2%				
Damage Threshold J/cm² [b]										
<100ns	0.1					0.8				
1µs	0.2					1				
300µs	2					5				
2ms	6					10				
Maximum Average Power W [d]	15, 25 with optional heat sink					15, 25 with optional heat sink				
Maximum Average Power Density W/cm²	20					20				
Uniformity over surface	±2% over central 50% of aperture					±2% over central 50% of aperture				
Fiber Adapters Available (see page 76)	ST, FC, SMA, SC					ST, FC, SMA, SC				
Weight kg	0.25					0.25				
Version										
Part Number: Standard Sensor	**7Z02936**					**7Z02934**				
StarLink Sensor: Direct USB link to PC (p. 75)	**787155**					**787153**				
Note: (a) Calibration curve is verified and adjusted at specified wavelengths.	Specified wavelengths: 248-266nm, 355nm, 1064nm and 2940nm.					Specified wavelengths: 193nm, 248-266nm, 355nm, 532nm, 1064nm and 2940nm.				
At other wavelengths, there may be an additional error up to the value given.	Max additional error at other wavelengths: ±2%.					Max additional error at other wavelengths: ±2%.				
Note: (b)						For wavelengths below 600nm, derate damage threshold to 60% of given values. Below 300nm, derate to 40% of given values.				

Note: (c) With the "user threshold" setting set to minimum. For other settings, the spec is for >7% of full scale or greater than twice the "user threshold", whichever is greater.
The user threshold is available with Nova II, Vega, StarLite or Juno. For other meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PE-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 77). The adapter can introduce up to 1% additional measurement error.
The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments. The user threshold setting represents the approximate minimum energy for pulse widths below ~50% of the pulse width setting. For longer pulse widths, the actual minimum may be higher. For highest accuracy, it is recommended to zero the sensor against the meter the first time it is used with a particular meter. For further information, see the FAQs on our Website.

Note: (d) A shock absorbing mounting post is available for situations in which sensor is mounted on a surface subject to shock or vibration. This can prevent false triggering and allow working at lower minimum energies. Note however, that in this case the maximum average power will be reduced to 10W without heat sink and 20W with heat sink (see accessory pages 76-77 for heat sink and mounting post).

Note: (e) With the Laserstar, Pulsar, USBI Quasar and Nova or Orion with adapter only 2 of the 5 pulse width settings are available. For the PE-C models the 30µs and 1ms settings and for the PE-BF models the 1ms and 10ms settings.

Note: (f) The 3000nm setting is calibrated for 10.6µm as well. To measure CO_2 laser, set to the 3000nm setting. The additional error for measuring 10.6µm is ±5%.

* For sensors drawings please see page 71

1.3.3 High Energy Pyroelectric Sensors

20µJ to 10J

Features

- Sensors with diffuser for high energies and high energy densities
- Metallic coating for high rep rates
- BF coating for highest damage threshold
- Wide spectral range. Measure YAG and harmonics and many more.
- Rep rates up to 10kHz
- Measure lasers with pulse widths up to 20ms

PE50-DIF-C

PE25BF-DIF-C

Model	**PE50-DIF-C**					**PE25BF-DIF-C**				
Use	**High rep rate. Complete calibration curve**					**Complete calibration curve. High damage threshold**				
Aperture mm	φ35					φ20				
Absorber Type	Metallic with diffuser					BF with diffuser				
Spectral Range µm [a]	0.19 - 3					0.19 - 2.2				
Surface Reflectivity % approx.	25					25				
Calibration Accuracy +/-% [a]	3					3				
Max Pulse Width Setting [e]	2µs	30µs	500µs	1ms	5ms	1ms	2ms	5ms	10ms	20ms
Energy Scales	10J to 200µJ	10J to 200µJ	10J to 2mJ	10J to 2mJ	10J to 20mJ	10J to 2mJ	10J to 2mJ	10J to 20mJ	10J to 20mJ	10J to 20mJ
Lowest Measurable Energy µJ [c,d]	20	20	100	120	200	100	150	200	200	300
Max Pulse Width ms	0.002	0.03	0.5	1	5	1	2	5	10	20
Maximum Pulse Rate pps	10kHz	5kHz	900Hz	450Hz	100Hz	250Hz	100Hz	50Hz	40Hz	20Hz
Noise on Lowest Range µJ	1	2	20	20	40	15	30	40	40	60
Additional Error with Frequency %	±2% to 2kHz ±4.5% to 5kHz	±2%	±1% to 750Hz	±2% to 400Hz	±1% to 80Hz	±1%	±1%	±1%	±1%	±2%
Linearity with Energy for >7% of full scale [c]	±1.5%					±2%				
Damage Threshold J/cm² [b]										
<100ns	1					3				
1µs	2					5				
300µs	20					25				
2ms	40					50				
Maximum Average Power W [d]	20, 30 with optional heat sink					20, 30 with optional heat sink				
Maximum Average Power Density W/cm²	100					120				
Uniformity over surface	±2.5% over central 20mm					±2.5% over central 10mm				
Weight kg	0.25					0.25				
Version										
Part Number: Standard Sensor	**7Z02939**					**7Z02941**				
StarLink Sensor: Direct USB link to PC (p. 75)	**787157**									
Notes: (a) Calibration curve is verified and adjusted at specified wavelengths. At other wavelengths, there may be an additional error up to the value given.	Specified wavelengths: 193nm, 248-266nm, 1064nm, 2100nm and 2940nm. Additional error at 193nm ±6%. Max additional error at other wavelengths not specified above: ±2%. 193nm reading may need 1min irradiation to stabilize.					Specified wavelengths: 193nm, 248-266nm, 355nm, 532nm, 1064nm and 2100nm. Additional error at 193nm ±6%. Max additional error at other wavelengths not specified above: ±3%. 193nm reading may need 1min irradiation to stabilize.				
Notes: (b)	For wavelengths >2µm, derate to 10% of above values. For beam size <=5mm. For 10mm beam, derate to 50% of above value.					For wavelengths below 600nm, derate to 60% of given values. For wavelengths below 240nm, derate to 1J/cm². For beam size <=5mm. For 10mm beam, derate to 50% of above values.				

Notes: (c) With the "user threshold" setting set to minimum. For other settings, the spec is for >7% of full scale or greater than twice the "user threshold", whichever is greater. The user threshold is available with Nova II, Vega, StarLite or Juno. For other meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PE-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 77). The adapter can introduce up to 1% additional measurement error. The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments. The user threshold setting represents the approximate minimum energy for pulse widths below ~50% of the pulse width setting. For longer pulse widths, the actual minimum may be higher. For highest accuracy, it is recommended to zero the sensor against the meter the first time it is used with a particular meter. For further information, see the FAQs on our Website.

Notes: (d) A shock absorbing mounting post is available for situations in which sensor is mounted on a surface subject to shock or vibration. This can prevent false triggering and allow working at lower minimum energies. Note however, that in this case the maximum average power will be reduced to 13W without heat sink and 25W with heat sink (see accessory pages 76-77 for heat sink and mounting post).

Notes: (e) With the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter only 2 of the 5 pulse width settings are available. For the PE-C models the 30µs and 1ms settings and for the PE-BF models the 1ms and 10ms settings.

*For sensors drawings please see page 71

1.3.3 High Energy Pyroelectric Sensors

100µJ to 40J

Features

- Sensors with diffuser for high energies and high energy densities
- BF coating for highest damage threshold
- BB coating for spectral flatness
- Wide spectral range. Measure YAG and harmonics and many more.
- Rep rates up to 250Hz
- Measure lasers with pulse widths up to 20ms
- PE50BF-DIFH-C sensor - highest damage threshold

PE50BF-DIF-C / PE50BF-DIFH-C

PE50BB-DIF-C

DIFFUSER IN

DIFFUSER OUT

Model	**PE50BF-DIF-C / PE50BF-DIFH-C**					**PE50BB-DIF-C**					
Use	**Complete calibration curve. Highest damage threshold**					**Removable diffuser. Spectrally flat**					
Diffuser	Fixed					Diffuser out			Diffuser in		
Aperture mm	φ35					φ46			φ33		
Absorber Type	BF with diffuser					BB			BB with diffuser		
Spectral Range µm [a]	0.19 – 2.2, 2.94					0.19 – 20			0.4 – 2.5		
Surface Reflectivity % approx.	25					5			15		
Calibration Accuracy +/-% [a]	3					3			3		
Max Pulse Width Setting [e]	1ms	2ms	5ms	10ms	20ms	3ms	10ms	20ms	3ms	10ms	20ms
Energy Scales	10J to 2mJ	10J to 2mJ	10J to 20mJ	10J to 20mJ	10J to 20mJ	10J to 2mJ	10J to 20mJ	10J to 20mJ	40J to 8mJ	40J to 8mJ	40J to 8mJ
Lowest Measurable Energy mJ [c,d]	0.2	0.4	0.8	0.8	0.8	0.1	0.1	0.2	0.5	5	5
Max Pulse Width ms	1	2	5	10	20	3	10	20	3	10	20
Maximum Pulse Rate pps	250Hz	100Hz	50Hz	40Hz	20Hz	40Hz	10Hz	5Hz	40Hz	10Hz	5Hz
Noise on Lowest Range µJ	40	80	200	200	200	15	15	20	40	60	80
Additional Error with Frequency %	±1%	±1%	±1%	±2%	±2%	±1%	±1%	±1%	±1%	±1%	±1%
Linearity with Energy for >7% of full scale [c]	±2%					±2%					
Damage Threshold J/cm² [b]	PE50BF-DIF-C		PE50BF-DIFH-C			Diffuser out			Diffuser in		
<100ns	4		6			0.3			3		
1µs	8		10			0.3			3		
300µs	30		30			1			10		
2ms	50		50			2			20		
Maximum Average Power W [d]	20, 30 with optional heat sink					10, 15 with optional heat sink			30, 40 with optional heat sink		
Maximum Average Power Density W/cm²	200					10			500		
Uniformity over surface	±2.5% over central 20mm					±2% over 70% of diameter			±2.5% over central 20mm		
Weight kg	0.25					0.25					
Version											
Part Number: Standard Sensor	**7Z02940**		**7Z02943**			**7Z02947**					
Previous Model Part Number						**7Z02866**					
StarLink Sensor: Direct USB link to PC (p. 75)	**787158**										
Notes: (a) Calibration accuracy at various wavelengths as specified here. At other wavelengths, there may be an additional error up to the value given.	Specified wavelengths: 193nm, 248-266nm, 355nm, 532nm, 1064nm, 2100nm and 2940nm. Additional error at 193nm ±6%. Max additional error at other wavelengths not specified above: ±3%. 193nm reading may need 1min irradiation to stabilize.					Calibrated at 1064nm Max additional error at other wavelengths is ±2%			Calibrated at 1064nm, 532nm and 2100nm only		
Notes: (b)	For wavelengths >2µm, derate to 10% of above values. For wavelengths below 600nm, derate to 60% of given values (for DIFH 50% of given values). For wavelengths below 240nm, derate to 1J/cm². For beam size <=5mm. For 10mm beam, derate to 50% of above values.										

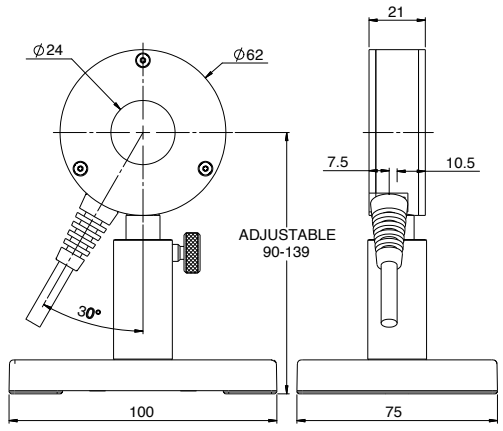
Notes: (c) With the "user threshold" setting set to minimum. For other settings, the spec is for >7% of full scale or greater than twice the "user threshold", whichever is greater. The user threshold is available with Nova II, Vega, StarLite or Juno. For other meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PE-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 77). The adapter can introduce up to 1% additional measurement error.
The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments. The user threshold setting represents the approximate minimum energy for pulse widths below ~50% of the pulse width setting. For longer pulse widths, the actual minimum may be higher. For highest accuracy, it is recommended to zero the sensor against the meter the first time it is used with a particular meter. For further information, see the FAQs on our Website.

Notes: (d) A shock absorbing mounting post is available for situations in which sensor is mounted on a surface subject to shock or vibration. This can prevent false triggering and allow working at lower minimum energies. Note however, that in this case the maximum average power will be reduced to 13W without heat sink and 25W with heat sink (see accessory pages 76-77 for heat sink and mounting post).

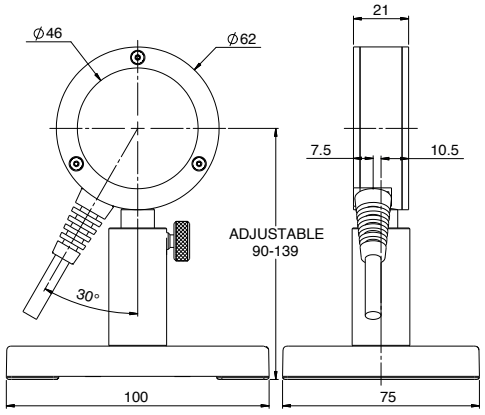
Notes: (e) With the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter only 2 of the pulse width settings are available. For the PE-BF models the 1ms and 10ms settings and for the PE-BB model the 3ms and 10ms settings.

*For sensors drawings please see page 71

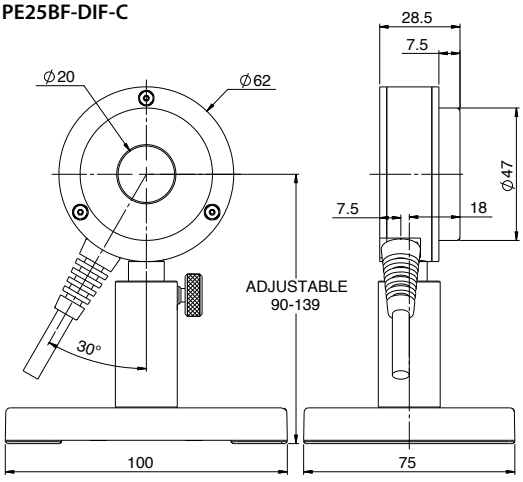
PE25-C / PE25BF-C



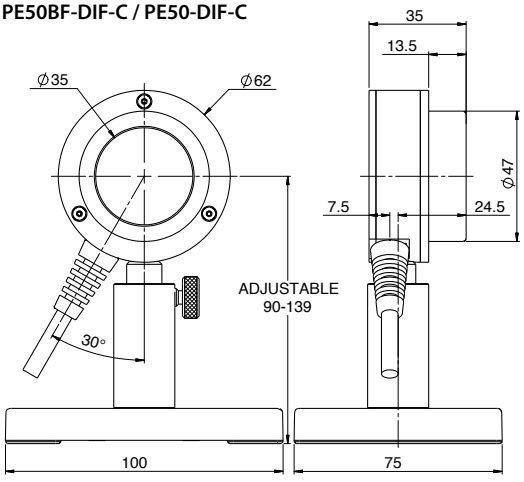
PE50-C / PE50BF-C



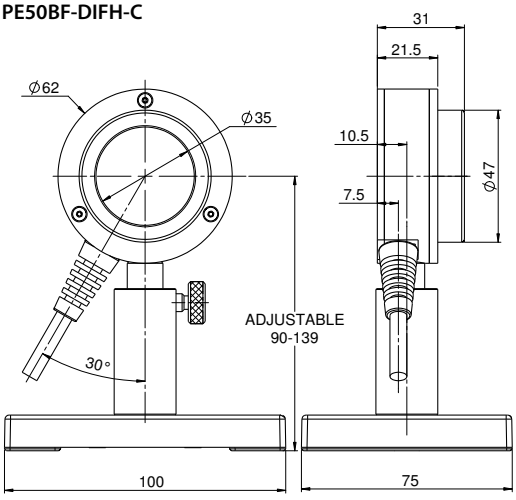
PE25BF-DIF-C



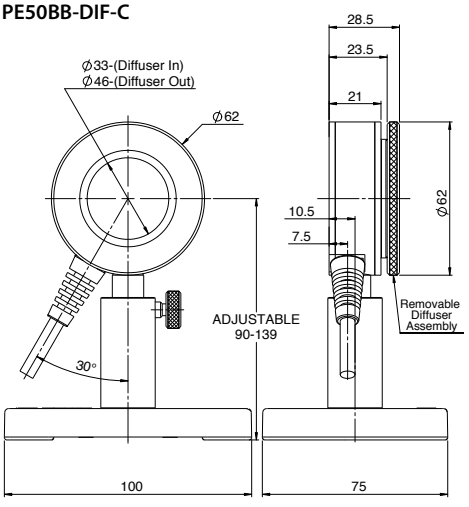
PE50BF-DIF-C / PE50-DIF-C



PE50BF-DIFH-C



PE50BB-DIF-C



1.3.3 High Energy Pyroelectric Sensors

10µJ to 40J

Features

- Removable diffusers
- PE50-DIF-ER-C mainly for NIR lasers
- PE100BF-DIF-C for very large beams
- Rep rates up to 10kHz
- Measure lasers with pulse widths up to 20ms

PE50-DIF-ER-C

DIFFUSER IN DIFFUSER OUT

PE100BF-DIF-C

DIFFUSER IN DIFFUSER OUT

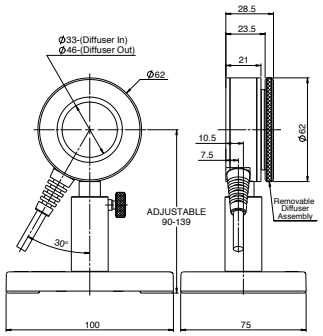
Model	**PE50-DIF-ER-C**										**PE100BF-DIF-C**									
Use	**Mainly for 1064nm, 2.1µm and 2.94µm**										**Very large aperture**									
Diffuser	Diffuser out					Diffuser in					Diffuser out					Diffuser in				
Aperture mm	φ46					φ33					φ96					φ85				
Absorber Type	Metallic					Metallic with diffuser					BF					BF with diffuser				
Spectral Range µm [a]	0.19 - 3					0.4 - 3					0.15 - 3					0.4 - 2.5				
Surface Reflectivity % approx.	50					50					20					50				
Calibration Accuracy +/-% [a]	3					3					3					3				
Max Pulse Width Setting [c]	2µs	30µs	500µs	1ms	5ms	2µs	30µs	500µs	1ms	5ms	1ms	2ms	5ms	10ms	20ms	1ms	2ms	5ms	10ms	20ms
Energy Scales	10J to 200µJ	10J to 200µJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	30J to 600µJ	30J to 600µJ	30J to 6mJ	30J to 6mJ	30J to 6mJ	10J to 2mJ	10J to 20mJ	10J to 20mJ	10J to 20mJ	10J to 20mJ	40J to 40mJ	40J to 40mJ	40J to 40mJ	40J to 40mJ	40J to 40mJ
Lowest Measurable Energy mJ [b, d]	0.01	0.01	0.06	0.08	0.1	0.05	0.05	0.3	0.4	0.5	0.4	0.7	1.5	1.5	1.5	2	3	5	5	5
Max Pulse Width ms	0.002	0.03	0.5	1	5	0.002	0.03	0.5	1	5	1	2	5	10	20	1	2	5	10	20
Maximum Pulse Rate pps	10kHz	5kHz	800Hz	400Hz	100Hz	10kHz	5kHz	800Hz	400Hz	100Hz	200	100	50	35	25	200	100	50	35	25
Noise on Lowest Range µJ	1	1	6	10	20	5	5	30	50	100	80	150	250	200	200	300	500	1000	600	600
Additional Error with Frequency %	±2% to 2kHz ±4.5% to 5kHz	±2%	±2%	±2%	±1% to 80Hz	±2% to 2kHz ±4.5% to 5kHz	±2%	±2%	±2%	±1% to 80Hz	±1%									
Linearity with Energy for > 10% of full scale [b]	±1.5%										±1%									
Damage Threshold J/cm²																				
<100ns	0.1					1.5					0.8					3				
1µs	0.2					3					1					3				
300µs	2					20					5					10				
2ms	6					60					10					25				
Maximum Average Power W [d]	15, 25 with optional heat sink					40, 60 with optional heat sink					15					40				
Maximum Average Power Density W/cm²	20					500					20					500				
Weight kg	0.3										1.2									
Version																				
Part Number	**7Z02948**										**7Z02942**									
Previous Model Part Number	**7Z02867**										**7Z02890**									
Notes: (a)	Calibrated at 532nm and 1064nm only					Calibrated at 1064nm, 2100nm and 2940nm					Calibrated at 532nm and 1064nm only					Calibrated at 532nm, 1064nm and 1550nm only				

Notes: (b) With the "user threshold" setting set to minimum. For other settings, the spec is for >10% of full scale or greater than twice the "user threshold", whichever is greater.
The user threshold is available with Nova II, Vega, StarLite or Juno. For other meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PE-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 77). The adapter can introduce up to 1% additional measurement error.
The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments. The user threshold setting represents the approximate minimum energy for pulse widths below ~50% of the pulse width setting. For longer pulse widths, the actual minimum may be higher. For highest accuracy, it is recommended to zero the sensor against the meter the first time it is used with a particular meter. For further information, see the FAQs on our Website.

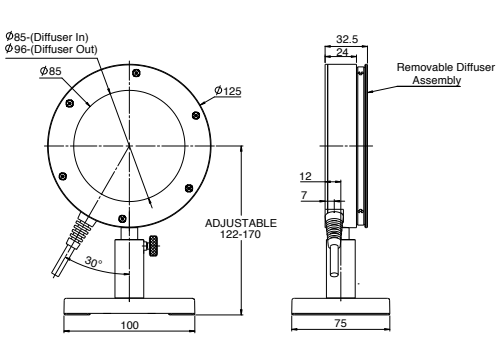
Notes: (c) With the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter only 2 of the 5 pulse width settings are available. For the PE50-DIF-ER-C, the 30µs and 1ms settings and for the PE100BF-DIF-C, the 1ms and 10ms settings.

Notes: (d) A shock absorbing mounting post is available for situations in which sensor is mounted on a surface subject to shock or vibration. This can prevent false triggering and allow working at lower minimum energies. Note however, that in this case the maximum average power will be reduced to 13W without heat sink and 25W with heat sink (see accessory pages 76-77 for heat sink and mounting post). Not available for model PE100BF-DIF-C.

PE50-DIF-ER-C



PE100BF-DIF-C



OPHIR Photonics
A Newport Corporation Brand

1.3.4 RP Sensors

200mW to 1500W

Features

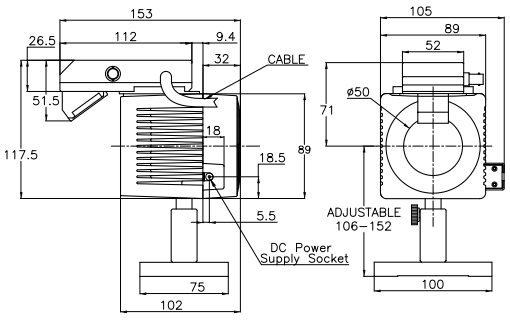
- Very long pulse repetitive lasers
- Energy measurement at high average powers
- Pulse rates to 15kHz
- Pulse widths to 200ms
- Temporal pulse shape measurement into scope

FL250A-RP

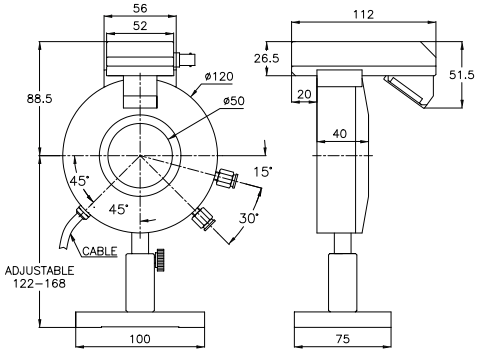
L1500W-LP1-RP

Model	FL250A-RP			L1500W-LP1-RP		
Use	**Long pulse lasers**			**High power pulsed lasers**		
Absorber Type	Broadband			LP1		
Spectral Range for Power µm	0.19 - 6			0.6 - 1.1		
Spectral Range for Energy µm	0.4 - 1.1			0.6 - 1.1		
Aperture mm	φ50mm			φ50mm		
Power Mode						
Power Range	200mW to 250W			10W to 1500W		
Power Scales	250W / 30W			1500W / 300W		
Power Noise Level mW	10			700		
Maximum Average Power Density kW/cm²	8			6		
Response Time with Display (0-95%) typ. s	2.5			2.7		
Power Accuracy +/-%	3			5 at 800nm and 1064nm		
Linearity with Power +/-%	1			2		
Minimum Average Power	200mW			10W		
Energy Mode						
Energy Range	100J to 1mJ			200J to 150mJ		
Energy Scales	100J to 30mJ			200J to 1J		
Energy Accuracy for energies >30% of full scale	±5%			±5%		
Minimum Energy	1mJ in repetitive mode. 50mJ in single shot mode			150mJ in repetitive mode. 500mJ in single shot mode		
Maximum Pulse Width ms	200			200		
Stabilization Time s	6			8		
Maximum Energy Density and Rep Rate vs. Pulse Width	Pulse Width	J/cm²	pps	Pulse Width	J/cm²	pps
	<10µs	0.3	15000	<10µs	0.05	15000
	0.5ms	5	1400	0.5ms	20	1400
	5ms	20	150	5ms	120	150
	100ms	400	7	100ms	2000	7
Pulse Shape Photodiode						
Response Time	1µs			1µs		
Peak Voltage into 50Ω	0.8V for 1kW peak power at 1064nm			0.3V for 1kW peak power at 1064nm		
System Specifications with USB PC Interface						
Frequency Measurement Accuracy	±0.01%			±0.01%		
Statistics Displayed	Min, Max, Std Dev			Min, Max, Std Dev		
Maximum Data Acquisition Rate	Sample to 15kHz, every pulse to 1000Hz in turbo mode					
Cooling	fan			water		
Weight kg	1.2			1.4		
Version	V1					
Part number	**7Z02921**			**7Z02919**		

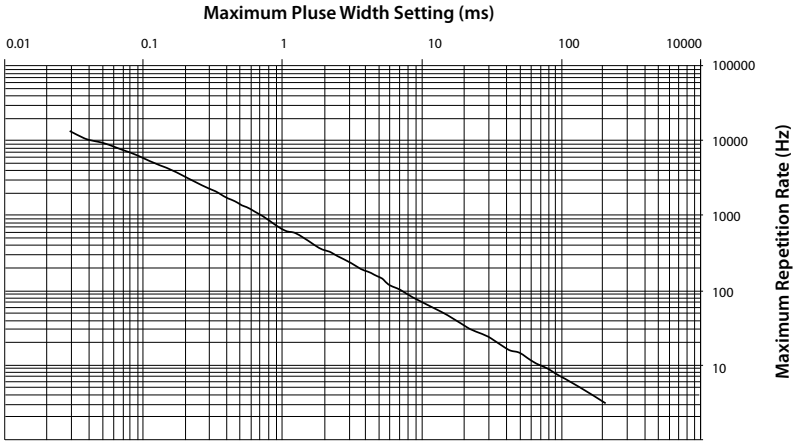
FL250A-RP



L1500W-LP1-RP



Maximum Laser Repetition Rate for a Given Pulse Width Setting for RP Heads



1.3.5 StarLink Direct to PC Energy Sensors

The StarLink Energy Sensor Series

The StarLink series is a select group of Ophir energy sensors that are provided with the Ophir Juno USB PC interface attached. The StarLink sensor is connected via a USB cable to the PC USB port and can then operate directly with the PC with no need for an Ophir power meter.

The StarLink package comes bundled with the celebrated Ophir StarLab software – the easiest to use and most sophisticated power/energy meter PC software available. Alternatively, StarLink sensors can be operated from the user's software via the COM Object interface provided or can work with LabVIEW via the drivers provided.

For more details about the computer interface options and StarLab software, see section 2.3.1 on page 105.

Below is a list of the StarLink energy sensors currently available together with the reference page for the specifications on the relevant sensor.

StarLink Sensor	StarLink P/N	Corresponding stand alone sensor	Ophir P/N	Data sheet page
PE10-C-StarLink	787152	PE10-C	7Z02932	66
PE25-C-StarLink	787156	PE25-C	7Z02937	67
PE25BF-C-StarLink	787154	PE25BF-C	7Z02935	67
PE50-C-StarLink	787155	PE50-C	7Z02936	68
PE50BF-C-StarLink	787153	PE50BF-C	7Z02934	68
PE50-DIF-C-StarLink	787157	PE50-DIF-C	7Z02939	69
PE50BF-DIF-C-StarLink	787158	PE50BF-DIF-C	7Z02940	70

1.3.6 Energy Sensors Accessories

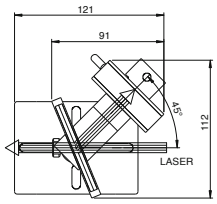
1.3.6.1 Accessories for Pyroelectric Sensors

Fiberoptic Adapter for Pyroelectric Sensors

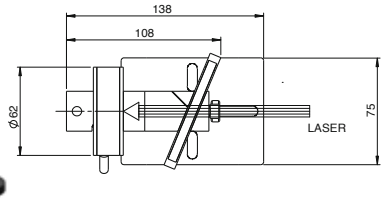
Oscilloscope Adapter for Pyroelectric Sensors

Heat Sink for PE-C Series Sensors

Beam Splitter Assembly



Beam splitter installed – reflected beam on sensor

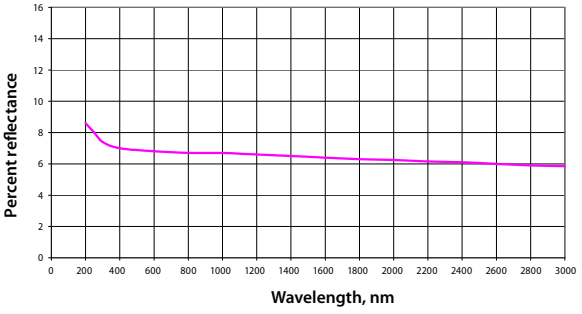


Beam Splitter removed – direct beam on sensor

Beam Splitter Specifications

Material	UV grade fused silica	
Spectral range	0.19 - 2.2µm	
Aperture	φ60mm	
Damage threshold for pulses	< 10ns PW 5J/cm²	>300µs PW >200J/cm²
Fraction split off	See graph	

F.S. Beam Splitter, 2 sided reflection unpolarized light



Accessory	Description	Part number			
Heat Sink	Heat sink that screws onto rear of PE25 and PE50 series sensors and allows working at over 50% higher average powers.	7Z08267			
Scope Adapter	Plugs in between the PE sensor and power meter. Provides BNC output to scope to see every pulse up to the maximum frequency of the sensor.	1Z11012			
Fiber Adapters	To mount fibers to sensors you need an adapter bracket and fiber adapter. All fiber adapters are compatible with the adapter bracket selected.				
Fiber Adapter Brackets	Mounting brackets to allow mounting fiber adapters to pyroelectric sensors.				
PE Sensor Family Type		Bracket P/N		Distance from fiber detector	
PD10-C / PD10-pJ-C / PD10-IR-pJ-C		7Z08275		10mm	
PE50-C / PE50BF-C		7Z08270		15mm	
PE9-C /PE10-C/ PE10BF-C / PE25-C / PE25BF-C		7Z08269		10mm	
Fiber Adapters	Fiber adapters for mounting to above brackets	SC type	ST type	FC type	SMA type
For all PE sensors above		7Z08227	7Z08226	7Z08229	1G01236
Beam Splitter Assembly	Beam Splitter Assembly to measure pulsed laser sources too energetic for direct measurement. The reading with the Beam Splitter can be calibrated by setting the laser to a lower energy that will not damage the sensor and then taking a measurement with the beam splitter and without and taking the ratio.	7Z17001			

1.3.6.1 Accessories for Pyroelectric Sensors - Continued

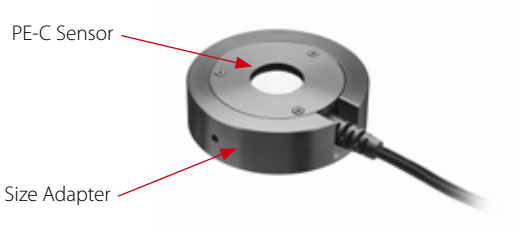
Nova PE-C Adapter

Shock Absorbing Mounting Post

Damage Threshold Test Slides

IR Phosphor Glass

PE-C to PE Size Adapter



Accessory	Description	Part number	
Shock Absorbing Mounting Post	Post with rubber encased thread to isolate sensor from vibration and prevent false triggering at low energy levels.	7Z08268	
Damage Threshold Test Plates	Test plates with same absorber coating as the sensor. For testing that laser beam is not above damage threshold (1such plate is included with sensor package).	Metallic type	BF type
		7E06031A	7E06031D
Nova PE-C Adapter	The adapter plugs between the Nova D15 socket and the smart plug of the PE-C sensor to allow the Nova to operate with PE-C series sensors. See PE-C spec sheet for details.	7Z08272	
PE-C to PE Size Adapter	The newer PE-C series sensors have a φ62mm diameter. The older PE series sensors have a φ85mm diameter. This adapter allows using the PE-C type sensors in jigs and setups that were originally designed for PE sensors.	7Z08273	
IR Phosphor Card	Glass slide (75x25mm) with phosphor coating (25x50mm) that visualizes spectral region 810-860nm, 900-1100nm and 1500-1600nm. Stands up to 1KW/cm^2 and 0.5J/cm^2. Self actuating, does not need charging from light source.	7F01235A	

1.3.6.2 Fast Photodetector Model FPS-1

Features

- Fast 1ns response time
- Measure temporal pulse shape of short or long pulses
- Wide spectral range 193 – 1100nm
- Optional attenuators and fiber adapters available
- Battery or wall cube operation

Description

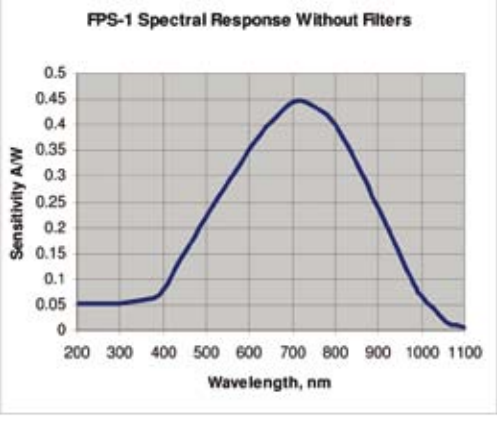
The FPS-1 fast photodetector is a compact easy to use very fast photodetector with wide spectral response.
It is used to measure the temporal pulse shape of laser pulses.

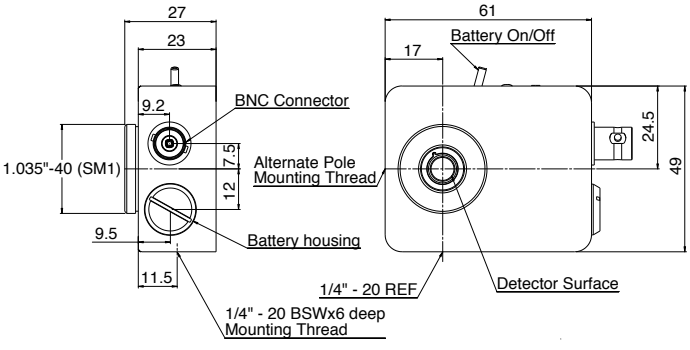
It has two modes of operation: Into 50Ohm load for ns high peak power pulses and 10kOhm load for longer lower peak power pulses.

In order to adjust the input intensity to the level appropriate for the detector, you may scatter the laser light off of a white matt surface and back off till the appropriate intensity is reached. Alternatively, or in addition, you may procure the ND attenuators listed below which may be stacked.

Specifications of the FPS-1 Fast Photodetector

Detector	Silicon PIN photodiode		
Spectral Range	193nm – 1100nm		
Detector Area	0.8mm^2		
Wavelength of Peak Sensitivity	720nm		
Spectral Response	See graph below		
Performance Specs	Into 50Ω load	Into 10kΩ load	
Sensitivity at Peak Wavelength	0.15V for 1W/cm^2 input	60V for 1W/cm^2 input	
Risetime 10-90%	1.5ns	3µs	
Maximum Output Voltage	10V		
Power Supply	12V A23 alkaline battery (40 hours lifetime). Also can be operated from 12VDC wall cube power supply. The power supply can be ordered from your local distributor.		
Input	Direct beam or from fiber connection.		
Dimensions	See drawing		
Thread	Front flange is threaded with male SM1 thread.		
Sensor Part Number	FPS-1 fast photodiode	7Z02505	
Optional Accessories and P/N	ND1 nom. x10 attenuator	7Z08200	
	ND2 nom. x50 attenuator	7Z08201	
	Fiber adapters	SMA	1G01236
		FC	7Z08229
		SC	7Z08227
		ST	7Z08226
	SM1 to M20 adapter (1 necessary for above adapters and/or attenuators)	1G02259	





1.3.7 OEM Solutions

Introduction

Many laser systems manufacturers need to have a measuring capability built into their systems.
Ophir is the world's leading supplier of OEM laser power/energy measurement instrumentation which can be built into host systems (such as medical, industrial, etc). With extensive experience accumulated in the field, Ophir offers the largest variety of OEM products and is therefore best able to satisfy customer requirements.

Many configurations possible

An OEM solution is usually needed to monitor laser performance in the system, and possibly to provide fast feedback for system control. Depending on your application, various configurations can be used, such as:

- Just a sensor, with raw analog output
- Sensor with electronics providing an amplified – or digital - output
- Complete instrument, including numeric display and/or PC interface
- Custom designed solution for special requirements

In the following pages, you will see a range of "standard" OEM sensors available; these are actually families of existing OEM sensors with typical specifications shown. They can be tailored as needed to fit your specific requirements.

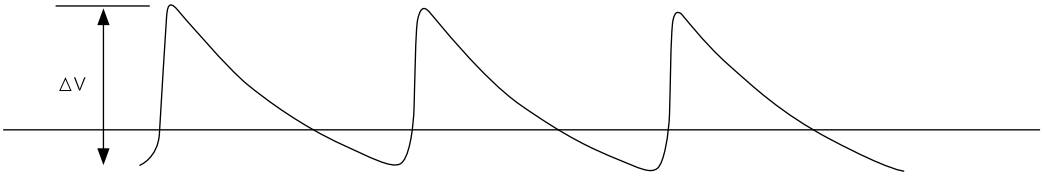
In addition to the products described below, Ophir has developed hundreds of other OEM solutions. Simply contact your Ophir representative who is likely to have just the right solution to your needs.

Standard Pyroelectric OEM Sensors - Introduction

Ophir manufactures three main types of pyroelectric OEM sensors:

- Low profile pyro sensors with no electronics with a BNC output to connect to the host electronics. These sensors can also be connected to an oscilloscope to measure pulse energy. Since the energy of pyro sensors is proportional to the peak to valley voltage output and not the maximum voltage output, the user has to take this into account in designing the electronic interface (see below).
- Low profile smart sensors to be used with Ophir smart meters. These PE-RE type sensors have a Remote Electronics (RE) module to enable interface with the meter.
- Compact pyroelectric sensors with built-in amplifiers and signal conditioners which put out a voltage proportional to energy and hold this voltage for a preset period after each pulse (see below).

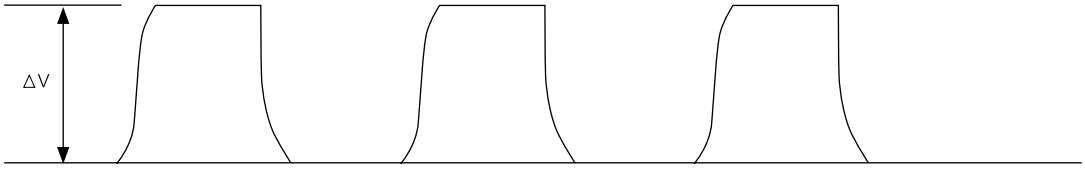
Typical output from a low-profile pyroelectric sensor appears as follows:



Ophir low profile pyroelectric sensor output for repetitively pulsing laser

In the example shown above using a low-profile sensor, note that energy is proportional to ΔV and not to the voltage above the zero level. Note also that the peak rapidly decays and therefore the output depends on pulse rate and duration. It follows therefore that in order to measure pyroelectric pulses, the voltage level must be known before the pulse and must also compensate for pulse rate (or work at a low enough pulse rate for the correction to be rendered negligible).

When using a sensor with built-in electronics, typical output appears as follows:



Output from Ophir pyroelectric OEM sensor with built-in signal conditioning

Note that the energy is now proportional to the output voltage and since the voltage is held for a fixed time, the output is much less dependent on pulse rate or duration.
In the above example, the user does not need to perform any signal conditioning but simply has to read the voltage level to determine the energy.

1.3.7.1 Standard OEM Pyroelectric Energy Sensors

2µJ to 20mJ

Features

- Compact
- Low Profile
- Low Cost

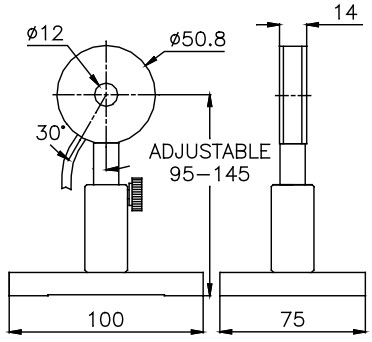
PE10-S

PE10-S-Q

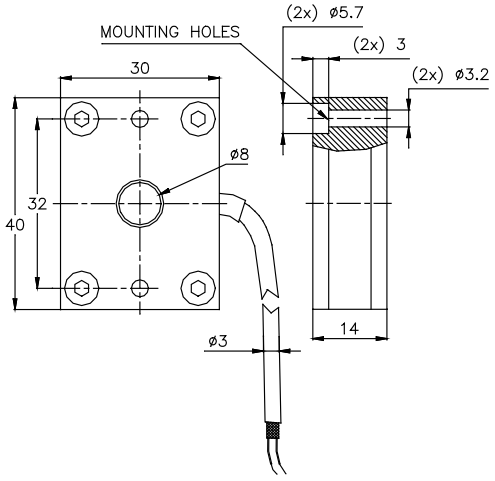
The following specifications refer to standard OEM sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

Model	**PE10-S**	**PE10-S-Q**
Features	**High sensitivity and rep rate**	**Very compact**
Aperture mm	12	8
Absorber Type	Metallic	Metallic
Spectral Range µm [a]	0.19-3	0.19-3
Surface Reflectivity % approx.	50	50
Calibration Accuracy +/-% [a]	3	3
Sensitivity (approx) at 1064nm	100V/J into 1MΩ	15V/J into 1MΩ and 5nF load
Max Pulse Width [b]	25us	500us
Maximum Pulse Rate pps [b]	400	100
Maximum Energy	20mJ	20mJ
Minimum Energy	2µJ	2µJ
Noise Equivalent Energy, approx	100nJ	100nJ
Output	BNC	Flying Leads
Damage Threshold J/cm²		
<100nm	0.1	0.1
1µs	0.2	0.2
300µs	3	3
Maximum Average Power W	2	2
Maximum Average Power Density W/cm²	50	50
Dimensions	Ø50.8 x 14mm	30 x 40 x 14mm
Part Number	**Consult Ophir representative**	**Consult Ophir representative**
Notes: (a)	At calibrated wavelength, standard 1064nm. Others on request.	
Notes: (b)	There is a trade off between repetition rate, sensitivity and maximum pulse width. If standard products are not suitable, these parameters can be tailored to customer requirements.	

PE10-S



PE10-S-Q



1.3.7.1 Standard OEM Pyroelectric Energy Sensors

0.1mJ to 10J

Features

- Compact
- Low Profile
- Low Cost
- With built-in electronics, for complete self-contained OEM solution with calibrated square pulse output

PE25-S / PE25BB-S

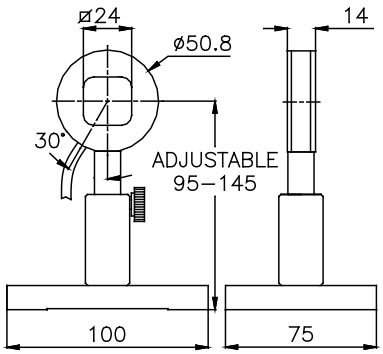
PE25-A-DIF-XXX-YYY(c)

PE25BB-S-DIF

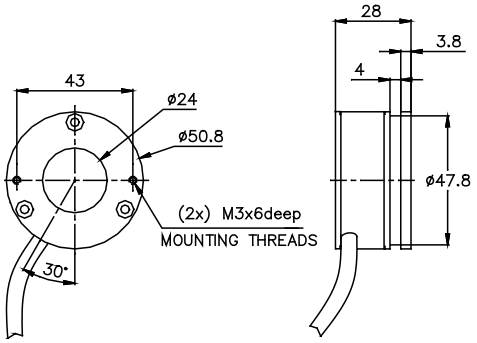
The following specifications refer to standard OEM sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

Model	**PE25-S**	**PE25BB-S**	**PE25BB-S-DIF**	**PE25-A-DIF-XXX-YYY(c)**
Features	**General purpose**	**Spectrally flat**	**High damage threshold**	**Built in amplifier. Output of calibrated square pulses**
Aperture mm	24 x 24	24 x 24	φ 20	φ 24
Absorber Type	Metallic	Broadband	Broadband + diffuser	Metallic + diffuser
Spectral Range µm	0.19-3 (a)	0.19-20 (a)	0.4-3 (a)	0.4-3
Surface Reflectivity % approx.	50	10	15	15
Calibration Accuracy +/-%	3 (a)	3 (a)	3 (a)	3
Sensitivity (approx) at 1064nm	9V/J into 1MΩ	5.5V/J into 1MΩ	2V/J into 1MΩ at 2.9µm	
Max Pulse Width	300us (b)	1ms (b)	1ms (b)	3ms
Maximum Pulse Rate pps	40 (b)	20 (b)	20 (b)	1000
Frequency Dependence				<±2% to maximum frequency
Pulse Width Dependence				<±2% to maximum pulse width
Noise Equivalent Energy, approx	5µJ	50µJ	150µJ	
Output	BNC	BNC	BNC	Customer specified Volt/J into input impedance of >3kΩ (d)
Output Hold				Hold time can be specified by customer (e)
Calibration Adjustment				Trimpot accessible through back cover of sensor
Maximum Energy	10J	10J	10J	10J
Minimum Energy	0.1mJ	1mJ	3mJ	0.1mJ
Damage Threshold J/cm²				
<100nm	0.1	0.3	3	1.5
1µs	0.2	0.3	3	3
300µs	2	1	10	8-100, depending on wavelength
Linearity with Energy				±2% for > 10% of full scale
Maximum Average Power W	10	10	30	50
Maximum Average Power Density W/cm²	10	10	300	
Dimensions	Ø50.8 x 14mm	Ø50.8 x 14mm	Ø50.8 x 18mm	Ø50.8 x 28mm
Part Number	**Consult Ophir representative**			
Notes: (a)	At calibrated wavelength, standard 1064nm. Others on request.			
Notes: (b)	There is a trade off between repetition rate, sensitivity and maximum pulse width. If standard products are not suitable, these parameters can be tailored to customer requirements.			
Notes: (c)	XXX denotes the calibration wavelength in µm and the YYY denotes the calibrated sensitivity in V/J.			
Notes: (d)	Output voltage is limited to 1.5 volt less than input V+. For example if input voltage is +6V and sensitivity is 10V/J, then maximum pulse energy is limited to 4.5V = output of 0.45J.			
Notes: (e)	Accuracy of hold time is ±20%. Maximum hold time limited to 50% of duty cycle. At end of hold time, voltage drops to below 0.2V.			

PE25-S / PE25BB-S



PE25-A-DIF-XXX-YYY (c)



1.3.7.1 Standard OEM Pyroelectric Energy Sensors

1mJ to 10J

Features

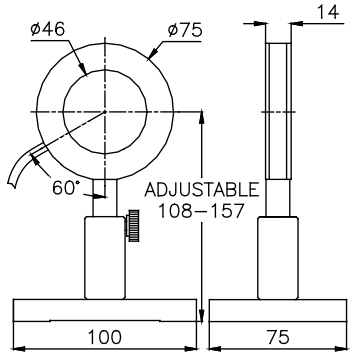
- Large apertures
- Compact
- Low Profile
- Low Cost

PE50-S / PE50BB-S

The following specifications refer to standard OEM sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

Model	**PE50-S**	**PE50BB-S**
Features	**Large aperture**	**Large aperture, spectrally flat**
Aperture mm	φ 46	φ 46
Absorber Type	Metallic	Broadband
Spectral Range µm [a]	0.19-3	0.19-20
Surface Reflectivity % approx.	50	5
Calibration Accuracy +/-% [a]	3	3
Sensitivity (approx) at 1064nm	2.5V/J into 1MΩ	1.8V/J into 1MΩ
Max Pulse Width [b]	800µs	2ms
Maximum Pulse Rate pps [b]	10	10
Maximum Energy	10J	10J
Minimum Energy	1mJ	10mJ
Noise Equivalent Energy, approx	20uJ	0.5mJ
Output	BNC	BNC
Damage Threshold for 10ns pulses J/cm²		
<100nm	0.1	0.3
1µs	0.2	0.3
300µs	2	1
Maximum Average Power W	20	15
Maximum Average Power Density W/cm²	10	10
Dimensions	Ø75 x 14mm	Ø75 x 14mm
Part Number	**Consult Ophir representative**	**Consult Ophir representative**
Notes: (a)	At calibrated wavelength, standard 1064nm. Others on request.	
Notes: (b)	There is a trade off between repetition rate, sensitivity and maximum pulse width. If standard products are not suitable, these parameters can be tailored to customer requirements.	

PE50-S / PE50BB-S



1.3.7.2 Examples of Custom OEM Energy Sensor Solutions

In addition to the standard OEM products described above, Ophir has accumulated over 25 years experience in developing products which are tailored to precise physical configurations provided by the OEM customer. These products include special antireflection coatings for specific wavelengths, specially configured pyroelectric sensors (with or without electronics), and much more. A number of these special OEM products are shown below.

OEM Pyroelectric Sensor with Built-In Amplifier

This sensor requires a compact cylindrical case with detector sensitivity reaching the diameter edge. The Ø32 x 30mm device has a built in amplifier.

Ophir Pyroelectric Sensor with add on OEM Electronics Module

This pyroelectric sensor is designed to be used as a Smart Sensor compatible with Ophir Smart meters, but also comes with an OEM I/F module providing calibrated analog voltage output to host system.

PE10-OEM Sensor

This is a highly compact OEM pyroelectric sensor, measuring only φ22 x 7.5mm with an AR coating on the surface for the wavelength of measurement. It can have a simple analog output or can be supplied with a circuit board to produce calibrated analog or digital RS232 or USB output.

PE-C RS232 OEM Sensors

The new PE – C Series of pyroelectric sensors has an option of RS232 output suitable for OEM use. The sensors give numerical energy output and the ranges and wavelength settings can be controllable from the host PC.
The input and output is available at the DB9 connector at the end of the cable.

Ordering Information:

The products shown above are examples of OEM solutions developed for specific customer applications. Please consult with your Ophir representative who will be happy to help you with any requirements you may have.

Power Meters

2.0 Power Meters & Interfaces

Power Meter Finder

The table below lists the specs and features of Ophir Power Meters and PC Interfaces

	Meters					
	Vega	**Nova II**	**LaserStar Dual Channel**	**LaserStar Single Channel**	**Nova**	**StarLite**
Digital Display	Yes	Yes	Yes	Yes	Yes	Yes
Display Color	Color	Monochrome	Monochrome	Monochrome	Monochrome	Monochrome
Analog Display	Yes	Yes	No	No	No	Yes
Rechargeable Battery	Yes	Yes	Yes	Yes	Yes	Yes
Detector Support						
Thermal Sensors	Yes	Yes	Yes	Yes	Yes	Yes
Photodiode Sensors	Yes	Yes	Yes	Yes	Yes	Yes
Pyroelectric Sensors	Yes	Yes	Yes	Yes	Yes	Yes
RP Sensors	No	No	Yes	Yes	No	No
BeamTrack Sensors*	Yes	Yes	No	No	No	Yes
Measurement Options						
Average Power	Yes	Yes	Yes	Yes	Yes	Yes
Energy per Pulse (Pyro. Sensors)	Yes	Yes	Yes	Yes	Yes	Yes
Single Shot Energy (Thermal Sensors)	Yes	Yes	Yes	Yes	Yes	Yes
Statistics	Yes	Yes	Yes	Yes	Yes	No
Analog Out	1V,2V,5V,10V	1V,2V,5V,10V	1V	1V	1V	1V
Trigger input & output	No	No	No	No	No	No
Real-Time Logging						
RS232	30Hz	30Hz	30Hz	30Hz	10Hz	N/A
GPIB	N/A	N/A	1500Hz	1500Hz	N/A	N/A
USB	2000Hz	2000Hz	N/A	N/A	N/A	N/A
Bluetooth	N/A	N/A	N/A	N/A	N/A	N/A
On-Board Data Storage	250K	50K	50K	50K	1K	No
Automation Interface	Yes for USB	Yes for USB	No	No	No	No
Labview VI's	Yes	Yes	Yes	Yes	Yes	No
Part number	7Z01560	7Z01550	7Z01601	7Z01600	7Z01500	7Z01565
Page in the catalog	89	91	93	93	95	97

Ophir power meters are true plug-and-play instruments. With all sensor information and calibration stored in the sensor plug, just plug in any one of over 150 Ophir sensors and the instrument is calibrated and configured to measure laser power and energy with that sensor.

*Position and size measurement capabilities on Vega, Nova II, StarLite and Juno. Power and single-shot energy measurement on all instruments.

Wireless Interface	PC Interfaces				
Quasar	**Juno**	**USBI**	**Pulsar-4**	**Pulsar-2**	**Pulsar-1**
N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A
Yes	Powered from USB	Powered from USB	No	No	No
Yes	Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Yes	Yes
No	No	Yes	No	No	No
No	Yes	No	No	No	No
Yes	Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Yes	Yes
No	No	1V	No	No	No
No	No	No	Yes	Yes	Yes
N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A
N/A	10,000Hz	2000Hz	25,000Hz	25,000Hz	25,000Hz
500Hz	N/A	N/A	N/A	N/A	N/A
No	No	No	No	No	No
No	Yes	Yes	Yes	Yes	Yes
No	Yes	Yes	Yes	Yes	Yes
7Z01300	7Z01250	7Z01200	7Z01201	7Z01202	7Z01203
103	101		102	102	102

Power Meters and PC Interfaces

Ophir power meters and PC interfaces work on the smart plug principle. This means that almost any Ophir power meter or PC interface can work – plug and play – with almost any of the wide range of Ophir sensors. Ophir power meters are also the most sensitive, lowest noise, most precise calibration units on the market thus giving the untmost performance from our smart sensors.
As for ease of use, only Ophir power meters have smart keys to give the easiest and most convenient user interface. The units also come with a versatile range of software to use seamlessly either with the Ophir software or the user's own.

Photodiode Sensors
Powers pW to Watts

Thermal Sensors
Powers mW to kW and
single shot energy

Pyroelectric Sensors
Energies pJ to Joules
Rep rates to 25kHz

Power Meters
with USB/RS232

Computer Interfaces
with USB/Bluetooth

Vega
color

Nova II
general

Juno
compact

Pulsar
1, 2, 4 channels

Nova
compact

Laserstar
2 channel

USB Interface
basic

Quasar
wireless

StarLab software

Software Solutions
StarLab, LabVIEW, StarCom
ActiveX & COM Object
Interfaces

LabVIEW

2.1 Power Meters

2.1.1 Vega

Color Screen Laser Power/Energy Meter

- Compatible with all Ophir thermal, BeamTrack, pyroelectric and photodiode sensors
- Brilliant color large size TFT 320x240 display
- Compact handheld design with rubberized bumpers and optimized 2 position kickstand
- Choice of digital or analog needle display
- Illuminated keys for working in the dark
- Analog output
- Log every point at up to 4000Hz with pyro sensors
- Non volatile data storage up to 250,000 points
- Laser tuning screen and power and energy log
- USB and RS232 interfaces with StarLab and StarCom PC applications, LabVIEW driver, COM Object Interface and ActiveX control (see pages 105-109)
- Soft keys and menu driven functions with on line help
- Many software features such as density, min/max, scaling etc.

The Vega is the most versatile and sophisticated handheld laser power/energy meter on the market. Just plug in one of the many Ophir sensors and you have a whole measurement laboratory at your fingertips. The bright color display gives unparalleled legibility and ease of interpreting information. The Vega has many on board features such as laser tuning, data logging, graphing, normalize, power or energy density units, attenuation scaling, max and min limits. The Vega can also display the power or energy with a high resolution simulated analog needle display.

The Vega can be operated either by battery or from an AC source with the charger plugged in at all times. Its bright display and backlit keys allow easy use in dark room conditions or with laser glasses on.

The built-in USB and RS232 interfaces and StarLab and StarCom PC software allow on-line processing of data or processing previously stored data; results are displayed graphically on a PC. To support PC interfacing, LabVIEW drivers, COM Object Interface and ActiveX controls are provided.

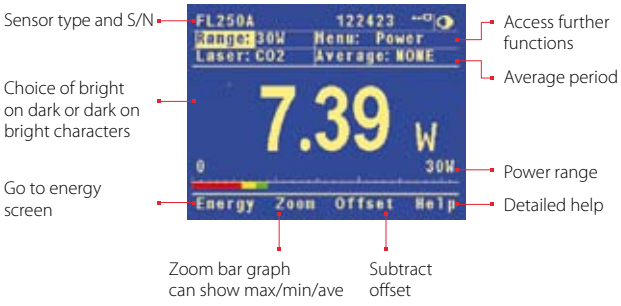
StarLab Software

Selected Screens

Digital Power Screen and Color Functions

- Choice of bright on dark or dark on bright characters
- Optimize colors for use with laser eye protection glasses
- Can average over selected period. Useful for unstable lasers
- Bar graph can show max / min / average in different colors

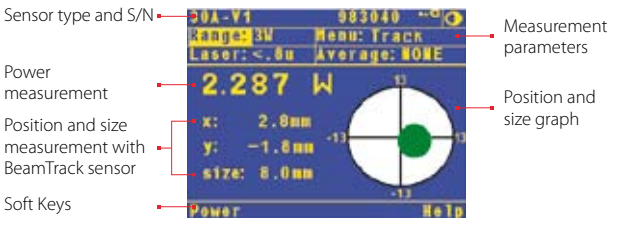
Standard Power Screen



BeamTrack Power/Position/Size Screen

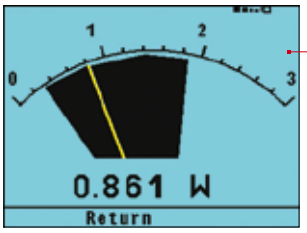
- Monitoring of laser beam size
- Accurate tracking of beam position to fractions of a mm
- Beam position and wander
- All the other features of standard power/energy meters

BeamTrack Power/Position/Size Screen



Analog Power Screen

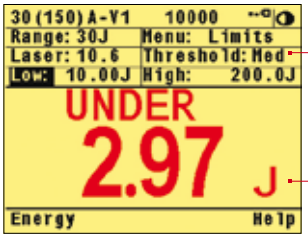
- Perfect for adjusting and maximizing laser power
- Persistent graphical display allows tracking of minimum maximum values measured
- Large analog needle with small digital display as well



Choice of smaller display with range, menu, laser and average headers.

Energy/Limits Screen

- Pulsed energy sensors (single or repetitive) and thermal sensors (single shot only).
- Frequency measurement with pulsed energy sensors.
- Limits screen with bright colored warning

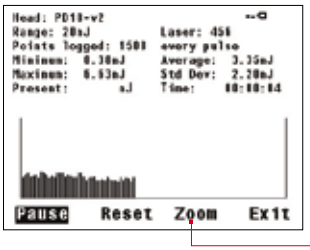


Energy threshold

Energy range

Energy Logging Screen

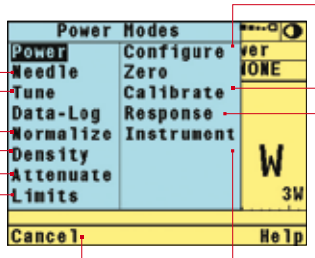
- Pyroelectric and thermal sensors
- Continuous scroll with up to 100 points on screen
- Full statistics
- Store data onboard and recall



Enlarge variation pulse to pulse

Additional Functions

- Press the menu choice on the main screen and many more options pop up as shown



Choose analog needle screen

Laser tune screen with continuous graph

Normalize so present reading is 1.00

Enter beam diameter and read in units of W/cm² or J/cm²

Put in factor to read input power with attenuator or beam splitter

Set for alarm if preset min or max limits exceeded

Return to previous menu

Set startup configuration

Adjust sensor calibration

Adjust sensor response time

Adjust power meter parameters

Specifications

Power Meter Features	Brilliant color TFT 320 x 240 pixel graphics LCD. Large 16mm digits. High resolution analog needle also can be chosen. Many screen features including power with multicolor bar graph, energy, average, exposure, frequency, graphs, scaling, special units, and more. Complete on line context sensitive help screens.
Outputs	USB, RS232 and user selectable 1, 2, 5 and 10 Volt full scale analog output.
Screen Refresh	15 times/sec
Case	Molded high impact plastic with optimized angle two level kickstand. Rubberized sides for easy grip and protection against damage.
Size	Folds to a compact 208mm L x 117mm W x 40mm H
Battery	Rechargeable NiMH batteries with typically 18 hours between charges. The charger can be ordered from your local distributor. The charger also functions as an AC adapter.
Data Handling	Data can be viewed on board or transmitted to pc: On Board: Non volatile storage of up to 250,000 data points in up to 10 files. Max data logging rate 4000[(a)] points/s. Transmitted to PC: Data transmission rate of ~500 points/s. RS232 baud rate of 38400.
Sensor Features	Works with Thermopile, BeamTrack, Pyroelectric and Photodiode sensors. Automatic continuous background cancellation with PD300 sensors Submicrojoule and multikilohertz capability with pulsed energy sensors.
Program Features	Preferred start up configuration can be set by user. User can recalibrate power, energy, response time and zero offset.
Notes: (a)	The above refers to the rate of logging every single point in turbo mode. Above that rate, the instrument will sample points but not log every single point.

Ordering Information

Item	Description	Ophir P/N
Vega	Vega color universal power meter for thermal, pyroelectric and photodiode sensors	7Z01560
Carrying Case	Carrying case 38x30x11 cm. For power meter and up to 3 sensors	1J02079
USB Cable for Vega	USB to mini DIN cable (1 unit supplied with Vega)	7E01205
RS232 Cable for Vega	D9 to mini DIN cable (1 unit supplied with Vega)	7E01206
Battery Pack for Vega	Replacement battery pack for the Vega	7E14007

2.1.2 Nova II

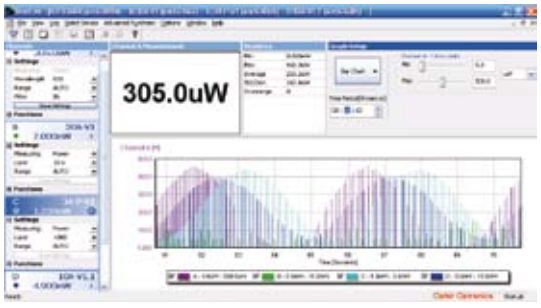
Versatile Laser Power/Energy Meter

- Compatible with all Ophir thermal, BeamTrack, pyroelectric and photodiode sensors
- Large high definition LCD display
- Choice of digital or analog needle display
- 2 position kickstand
- Backlighting and rechargeable battery
- Analog output
- Log every point at up to 4000Hz with pyro sensors
- Non volatile data storage up to 54,000 points
- Laser tuning screen and power and energy log
- USB and RS232 interfaces with StarLab and StarCom PC applications, LabVIEW driver, COM Object Interface and ActiveX control (see pages 105-109)
- Soft keys and menu driven functions with on-line help
- Many software features such and density, min/max, scaling etc.

The Nova II is the most versatile and sophisticated handheld laser power/energy meter on the market. Just plug in one of the many Ophir sensors and you have a whole measurement laboratory at your fingertips. The Nova II has many on-board features such as laser tuning, data logging, graphing, normalize, power or energy density units, attenuation scaling, max and min limits. The Nova II can also display the power or energy with a high resolution simulated analog needle display.

The Nova II can be operated either by battery or from an AC source with the charger plugged in at all times. Its backlight allows illumination of the power meter in low light conditions.

The built-in USB and RS232 interfaces and StarLab and StarCom PC software allow on-line processing of data or processing previously stored data; results are displayed graphically on a PC. To support PC interfacing, LabVIEW drivers, Com Object Interface and ActiveX controls are provided.



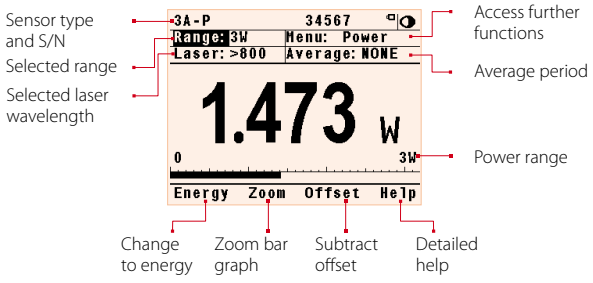
StarLab Software

Selected Screens

Digital Power Screen

- CW industrial, medical and scientific lasers
- pW to Multi kW with appropriate sensors
- Can average over selected period. Useful for unstable lasers
- Fast response bar graph

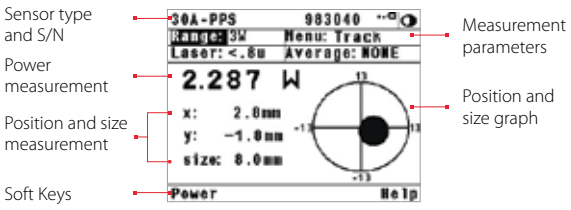
Standard Power Screen



BeamTrack Power/Position/Size Screen

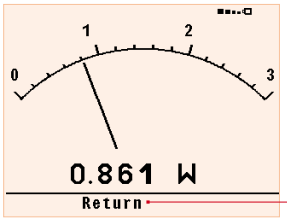
- Monitoring of laser beam size
- Accurate tracking of beam position to fractions of a mm
- Beam position and wander
- All the other features of standard power/energy meters

BeamTrack Power/Position/Size Screen



Analog Power Screen

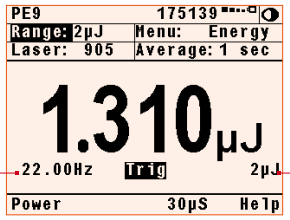
- Perfect for adjusting and maximizing laser power
- Large analog needle with small digital display as well



Choice of smaller ,display with range menu, laser and average headers

Energy Screen

- Pulsed energy sensors (single or repetitive) and thermal sensors (single shot only)
- Frequency measurement with pulsed energy sensors

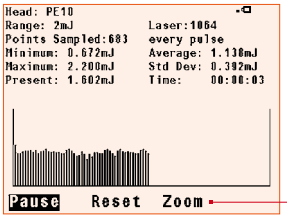


Frequency

Energy range

Energy Logging Screen

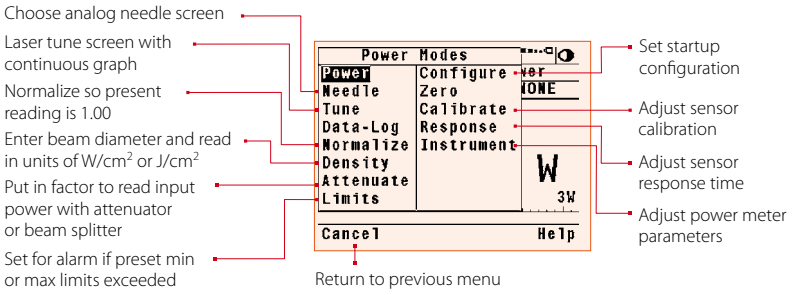
- Pyroelectric and thermal sensors
- Continuous scroll with up to 100 points on screen
- Full statistics
- Store data onboard and recall



Enlarge variation pulse to pulse

Additional Functions

- Press the menu choice on the main screen and many more options pop up as shown



Choose analog needle screen

Laser tune screen with continuous graph

Normalize so present reading is 1.00

Enter beam diameter and read in units of W/cm^2 or J/cm^2

Put in factor to read input power with attenuator or beam splitter

Set for alarm if preset min or max limits exceeded

Set startup configuration

Adjust sensor calibration

Adjust sensor response time

Adjust power meter parameters

Return to previous menu

Specifications	
Power Meter	High legibility 320 x 240 pixel graphics LCD with switchable electroluminescent backlight. Large 18mm digits. High resolution analog needle also can be chosen.
Features	Many screen features including power with bar graph, energy, average, exposure, frequency, graphs, scaling, special units, and more. Complete on line context sensitive help screens.
Outputs	USB, RS232 and 1, 2, 5 and 10 volt full scale analog output.
Screen Refresh	15 times/sec
Case	Molded high impact plastic with two level kickstand.
Size	Folds to a compact 208mm Lx 117mm Wx 40mm H
Battery	Rechargeable NiMH batteries with typically 18 hours between charges. The charger can be ordered from your local distributor. The charger also functions as an AC adapter.
Data Handling	Data can be viewed on board or transmitted to PC: On Board: Non volatile storage of up to 54000 data points in up to 10 files. Max data logging rate 4000 (a) points/s. Transmitted to PC: Data transmission rate of ~500 points/s. RS232 baud rate of 38400.
Sensor Features	Works with Thermopile, BeamTrack, Pyroelectric and Photodiode sensors. Automatic continuous background cancellation with PD300 sensors. Submicrojoule and multikilohertz capability with pulsed energy sensors.
Program Features	Preferred startup configuration can be set by user. User can recalibrate power, energy, response time and zero offset.
Notes: (a)	The above refers to the rate of logging every single point in turbo mode. Above that rate, the instrument will sample points but not log every single point.

Ordering Information

Item	Description	Ophir P/N
Nova II	Nova II universal power meter for thermal, pyroelectric and photodiode sensors	7Z01550
Carrying Case	Carrying case 38x30x11 cm. For power meter and up to three sensors	1J02079
Nova II USB Cable	USB to mini DIN cable (1 unit supplied with Nova II)	7E01205
Nova II RS232 Cable	D9 to mini DIN cable (1 unit supplied with Nova II)	7E01206
Battery Pack	Replacement battery pack for the Nova II	7E14007

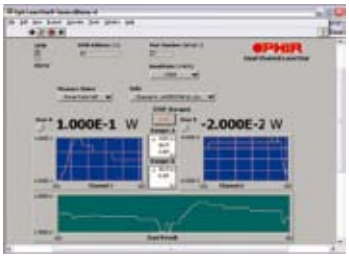
2.1.3 Laserstar

Versatile Laser Power/Energy Meter

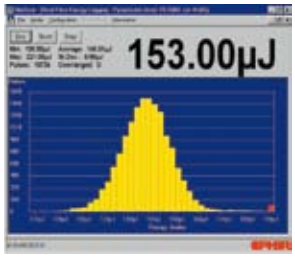
- Two models available: dual and single channel
- Single channel model can be upgraded to dual channel
- Compatible with all Ophir thermopile, pyroelectric, photodiode and RP sensors
- Large LCD display
- Backlighting and rechargeable battery
- Screen graphics and statistics (std dev. min, max)
- Analog output
- Built-in RS232 interface
- Log every data point at >1500Hz with pyroelectric sensors
- Non-volatile data storage up to 54,000 points
- Laser tuning screen and power log
- Audio sound for laser tuning and low battery
- RS232 interface with StarCom PC application software and LabVIEW driver (see pages 107-109)
- GPIB option (IEEE488.1)
- NIST traceable
- CE marked
- Soft keys, menu-driven

IEEE 488 GPIB Cable for LaserStar

The dual channel model enables user to simply plug in any of Ophir's thermal, pyroelectric, photodiode or RP sensors and measure two channels independently, or the ratio or difference between them in real time.
Up to 10 data files (54,000 points total) can be stored for onboard review or downloading to computer even if Laserstar has been switched off. The built-in RS232 interface and StarCom PC software allow on-line processing of data or processing previously stored data; results are displayed graphically on a PC. To support PC interfacing, LabVIEW drivers are provided.



LabVIEW

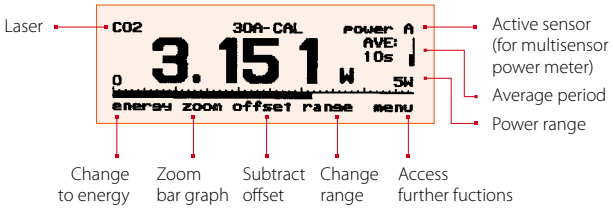


StarCom Software

Selected Screens

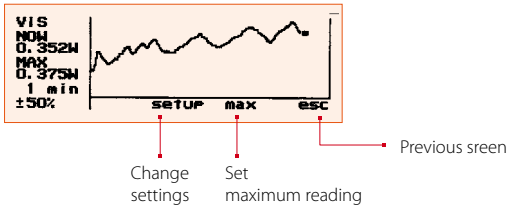
Digital Power Screen

- CW industrial, medical and scientific lasers
- pW to multi kW with appropriate sensors
- Can average over selected period. Useful for unstable lasers
- Fast response bar graph



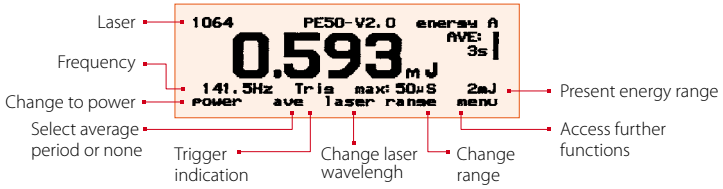
Laser Tuning Screen or Power Log Screen (not shown)

- Maximizing laser power
- User selected time period and zoom
- Option of audio tune tone for maximizing laser power



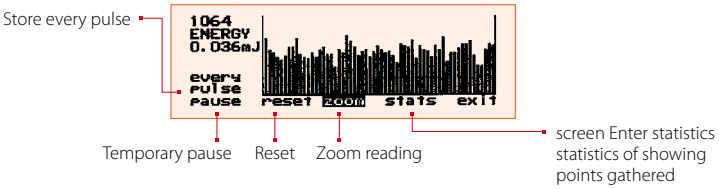
Energy Measurement Screen

- Pyroelectric and thermal sensors - single pulse
- Pyroelectric frequency measurement



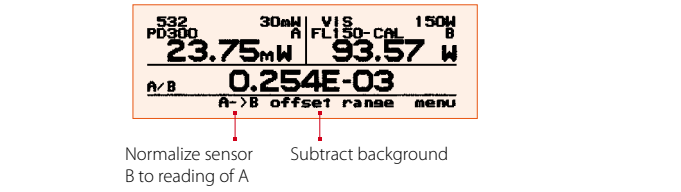
Energy Log Screen

- Pulsed energy sensors
- Thermal sensors - successive single pulses
- Continuous scroll
- Energy statistics



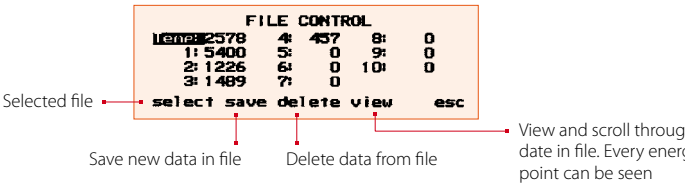
Ratio Screen

- Two independent sensors
- Measure ratio, sum, difference
- Normalize one sensor to the other



Data Storage and Transmission

- Non-volatile storage of power and energy logging data
- Store in up to 10 files and transmit to PC
- PC using StarCom Windows program provided



Specifications

Power Meter	High legibility 64 x 240 pixel graphics supertwist LCD with switchable, electroluminescent backlight which operates from charger or battery. Large 17mm digits. Screen refresh 15Hz.
Features	Many screen features including: power with bargraph, energy, average, exposure, frequency, graphs and more.
Outputs	RS232 and analog output 1V f.s.
Screen Refresh	15 times /sec
Case	Molded high-impact plastic with swivel display and EMI conductive shielding, to allow use even in proximity to pulsed lasers.
Size	Folds to a compact 228mm W x 195mm L x 54mm H.
Battery	Rechargeable 18 hours between charges. The charger can be ordered from your local distributor. The charger also functions as AC adapter.
Multisensor Option	Two sensors can be connected and measure independently, or the ration, sum or difference of the two can be displayed.
Data Handling	Data can be viewed on board or transmitted to PC: On Board: Non volatile storage of up to 54,000 data points in up to 10 files. Max data logging rate >1500 points/s. Transmitted to PC: Data transmission rate of ~500 points/s. RS232 baud rate of 38400.
Sensor Features	Works with thermal, pyroelectric, photodiode and RP sensors. Automatic, continuous, background cancellation with PD300 sensors. Submicrojoule and multikilohertz capability with pulsed energy sensors.
Program Features	Preferred startup configuration can be set by user. User can recalibrate power, energy, response time and zero offset.

Ordering Information

Item	Description	Ophir P/N
Laserstar	Laserstar single channel universal power meter for thermal, pyroelectric, photodiode and RP sensors	7Z01600
Laserstar 2 Channel	Laserstar with dual channel capability including ration and difference measurement	7Z01601
RS232 Cable for Laserstar	Cable RS232 D9 - D25 (1 unit supplied with Laserstar)	7E01121
Laserstar Battery Pack	Laserstar NiMH Battery update Kit	7Z14006A
Laserstar IEEE Option	IEEE GPIB adapter for Laserstar (see page 99)	78300

2.1.4 NOVA

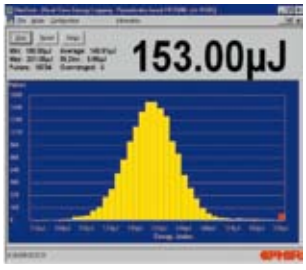
Compact and Durable Power / Energy Meter

- Compact and durable
- Compatible with all Ophir sensors: thermal, pyroelectric and photodiode (Not compatible with PE-C series of pyroelectric sensors)
- Single shot energy measurement with thermal sensors
- Optional RS232 interface with StarCom PC application and LabVIEW driver (see pages 107-109)
- Power and energy logging with graphical display and statistics
- Power averaging
- Easy to use soft keys, menu-driven
- Screen graphics
- Backlight and rechargeable battery
- Analog output
- EMI rejection

RS232 cable for Nova

Compatible with the complete range of Ophir thermal (power and energy), pyroelectric and photodiode sensors, Nova is truly versatile:measuring power or energy from pJ and pW to hundreds of Joules and thousands of Watts. With the optional scope adapter, you can connect your pyro sensor to an oscilloscope and see every pulse up to the maximum frequency permitted by the sensor.
Smart connector sensors automatically configure and calibrate Nova when plugged in. Soft keys guide you through the screen graphics. Finished working? Your configuration can be saved for future use.
Nova's exclusive autoranging tune screen displays laser power graphically and displays maximum power. Zoom and time scale can be adjusted by user.

The optional RS232 interface and StarCom PC software allow on-line processing of data or processing previously stored data; results are displayed graphically on a PC. To support PC interfacing, LabVIEW drivers are provided.



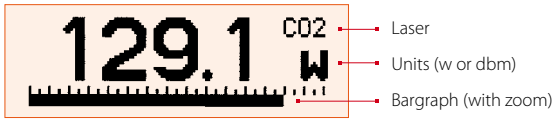
StarCom Software

LabVIEW

Selected Screens

Digital Power Screen

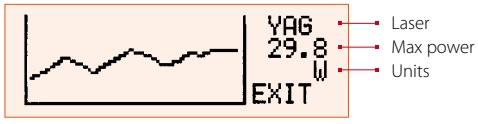
- CW industrial, medical and scientific lasers
- pW to multi kW with appropriate sensors



Press Menu button or soft keys to make legends visible (not shown).

Laser Tuning Screen or Power Log Screen (not shown)

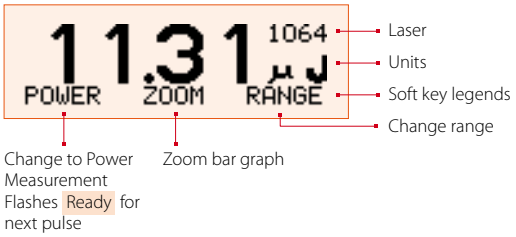
- Maximizing laser power
- User selected time period and zoom



Press Menu button or soft keys to make legends visible.

Energy Measurement Screen

- Pyroelectric and thermopile sensors-single pulse
- Pyroelectric frequency measurement (not shown)



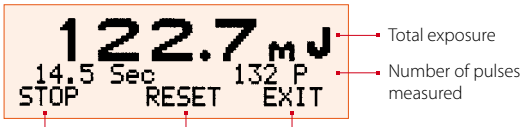
Energy Log Screen

- Pyroelectric sensors
- Thermopile sensors-successive single pulses
- Continuous scroll
- Energy statistics

Press Menu button or soft keys to make legends visible (not shown)

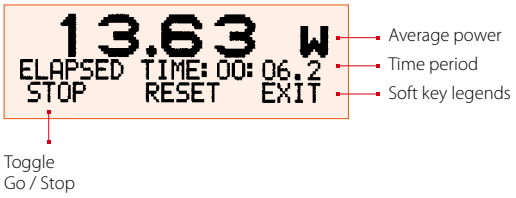
Pyroelectric Exposure Screen

- Sum or average energies over user selected time period / number of pulses
- Medicine, photolithography



Average Screen

- Thermopile, photodiode and pyroelectric sensors (Does not operate with PE-C series of pyroelectric sensors)
- Periodic (1/3 sec to 30 sec) or continuous (10 sec to 1 hour) average for fast-changing or slow-changing laser



Specifications

Power Meter	High legibility 32 x 122 pixel graphics supertwist LCD with switchable electroluminescent backlight. Large 12mm digits.
Features	Many screen features: including power with bar graph, energy, average, exposure, frequency, graphs, and more.
Outputs	RS232 and analog output 1V f.s. (optional)
Screen Refresh	15 times / sec.
Case	Molded high-impact plastic with kickstand and EMI conductive shielding, to allow use even in proximity to pulsed lasers.
Size	Very compact: 205 x 95 x 39mm.
Battery	Rechargeable 12 volts. 22 hours use between charges. The charger can be ordered from your local distributor. The charder also functions as AC adapter.
Data Handling	Data can be viewed on board or transmitted to PC: On Board: Max data logging rate >10 points/s Transmitted to PC: Data transmission rate of ~50 points/s. RS232 baud rate of 19200
Sensor features	Works with thermopile, pyroelectric, and photodiode sensors. Automatic, continuous, background cancellation with PD300 sensors. Submicrojoule and multikilohertz capability with model PE sensors. All sensors use smart connector containing configuration information.
Program features	Preferred startup configuration can be set by user. User can recalibrate power or energy. Response time. Zero offset.

Ordering Information

Item	Description	Ophir P/N
Nova	Nova universal power meter for thermal, pyroelectric and photodiode sensors	7Z01500
Nova PE-C Adapter	Adapter to allow Nova to operate with PE-C series pyroelectric sensors. Plugs between Nova D15 socket and PE-C D15 plug	7Z08272
Carrying Case	Carrying case 38x30x11cm. For display and up to three sensors	1J02079
Nova RS232 assemblies - allow Nova power meter to communicate with PC and be controlled by PC		
Nova RS232 Assembly	RS232 adapter with standard 2 meter cable (including software) (see page 99)	78105
Nova RS232 Assembly	RS232 adapter with 5 meter cable (including software)	781052
Nova RS232 Assembly	RS232 adapter with 8 meter cable (including software)	781051
Battery Pack	Replacement battery pack for Nova	7Z11200

2 .1.5 StarLite

Low Cost Power / Energy Meter

- Compatible with all standard Ophir Thermal, BeamTrack, PE-C Pyroelectric and Photodiode sensors
- Brilliant large size TFT 320x240 display
- Compact handheld design with rubberized bumpers and optimized kickstand
- Choice of digital or analog needle display
- Analog output
- Easy to use soft keys
- Easy measurement configuration with context sensitive help
- Backlighting and rechargeable battery
- Single shot energy measurement with thermal sensors
- Power averaging
- Resizable Screen graphics
- EMI rejection

StarLite is a low cost power / energy meter capable of measuring power or energy from pJ and pW to hundreds of Joules and thousands of Watts. It also supports position and size measurement with the BeamTrack family of sensors. StarLite can also display the power or energy with a high resolution simulated analog needle display.

All StarLite measurement screens can be configured to either show the measurement parameters or to hide them in order to maximize the graphical and numeric displays.

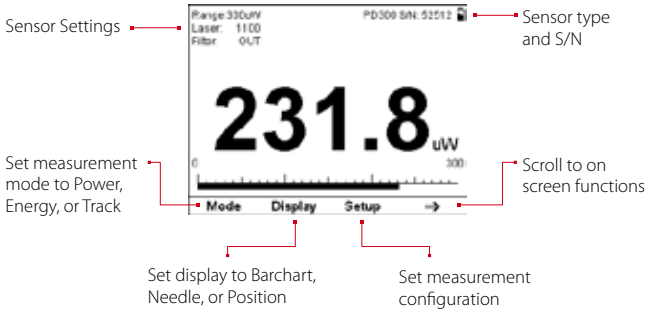
StarLite can be operated either by battery or from an AC source with the charger plugged in at all times. Its backlight allows illumination of the power meter in low light conditions.

Selected Screens

Digital Power Screen

- CW industrial, medical and scientific lasers
- pW to Multi kW with appropriate sensors
- Can average over selected period. Useful for unstable lasers.
- Fast response bar chart

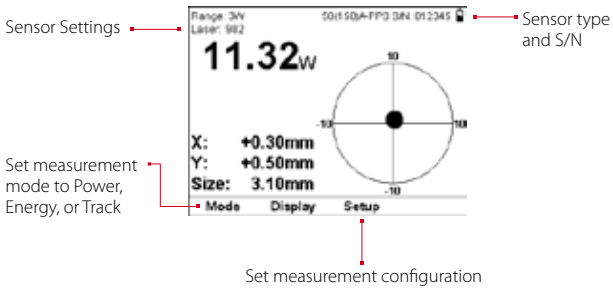
Barchart Display of Power Measurement



BeamTrack Power/Position/Size Screen

- Monitoring of laser beam size
- Accurate tracking of beam position to fractions of a mm
- Power measured at the same time

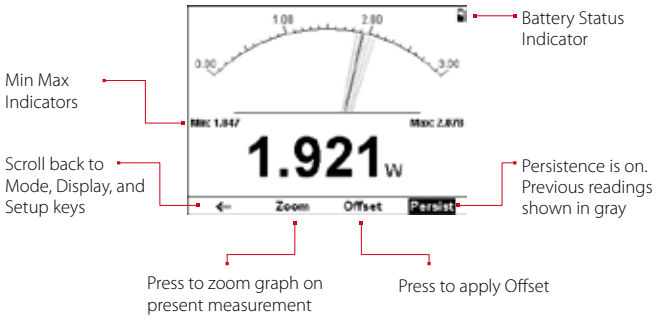
BeamTrack Position and Size Screen



Analog Needle Screen

- Perfect for adjusting and maximizing laser power or energy
- Persistent graphical display allows tracking of minimum maximum values measured
- Large analog needle with small digital display as well

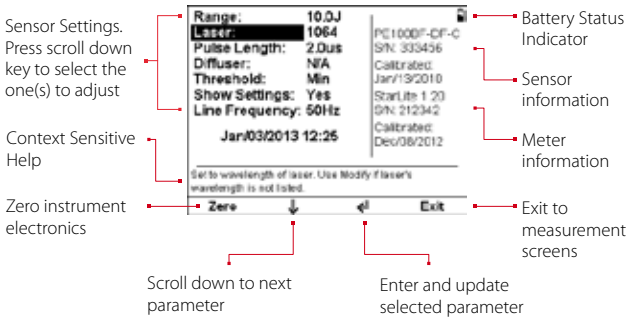
Large Analog Needle with Persistence



Configuration Screen

- Easy adjustment of all measurement configuration parameters
- Context sensitive help for selected parameter
- Sensor and meter information provided

Configuration Screen



Specifications

Power Meter	High legibility TFT 320 x 240 pixel graphics LCD. Large 16mm digits. High resolution analog needle also can be chosen.
Features	Power, single shot energy, energy and frequency of high rep rate lasers, position, and size.
Outputs	1V Full Scale analog output.
Screen Refresh	15 times/sec
Case	Molded high impact plastic with optimized angle kickstand. Rubberized sides for easy grip and protection against damage.
Size	Folds to a compact 213mm L x 113mm W x 40mm H
Battery	Rechargeable Li-ion batteries with typically 8 hours between charges. The charger can be ordered from your local distributor. The changer also functions as an AC adapter.
Sensor Features	Works with Thermopile, BeamTrack, Pyroelectric and Photodiode sensors. Automatic continuous background cancellation with PD300 sensors. Submicrojoule and multikilohertz capability with pulsed energy sensors.

Ordering Information

Item	Description	Ophir P/N
StarLite	StarLite universal power meter for Thermal, BeamTrack, Pyroelectric and Photodiode sensors	7Z01565
Carrying Case	Carrying case 38x30x11 cm. For power meter and up to 3 sensors	1J02079
USB Cable for StarLite	USB-A to MICRO-B cable for field upgrade support (1 unit supplied with StarLite)	7E01279
Battery Pack for StarLite	Replacement battery pack for the StarLite	7E14008

2.1.6 ACCESSORIES

RS232 Module for Nova

Plug in module allows transfer of power and energy data to PC and remote control of power meters from PC. Includes manual and StarCom application program (refer to page 107).

IEEE488 GPIB for Laserstar

Option available with Laserstar power meter allowing Laserstar to operate with GPIB protocol. The option comes with StarCom software and also LabVIEW VIs to build LabVIEW applications.

Carrying Cases

Carrying case for Vega, Nova II, StarLite or Nova power meters and up to 3 sensors.

Ordering Information

Item	Description	Ophir P/N
Nova RS232 Assembly	RS232 adapter with standard 2 meter cable (including software)	78105
Nova RS232 Assembly	RS232 adapter with 5 meter cable (including software)	781052
Nova RS232 Assembly	RS232 adapter with 8 meter cable (including software)	781051
Laserstar IEEE Option	IEEE GPIB adapter for Laserstar	78300
Carrying Case for Vega, Nova II, StarLite and Nova	Carrying case 38x30x11 cm. For power meter and up to three sensors	1J02079

PC Connectivity Options for Power/Energy Measurement

Ophir Pyroelectric, Thermal and Photodiode sensors measure at up to 25,000 points per second

Sample data with Ophir power meter at up to 4000 points per second

Ophir power meter capable of on board storage of data of up to 250,000 points and data storage rate of up to 4000 points per second

Ophir sensor to USB interfaces with up to 4 channel connectivity

Ophir Quasar interface with wireless connectivity

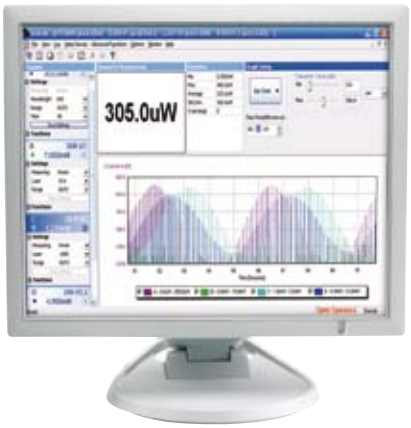
Transmit real time data to PC at up to 25,000 points/s per channel (sensor limited) via USB

Transmit stored data or real time data to PC via USB or RS232

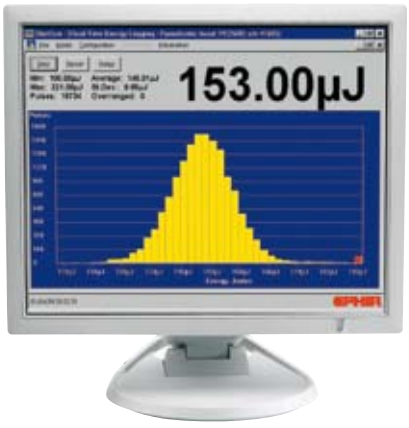
Transmit real time data to PC at 500 points per second via Bluetooth

StarLab software (data transmitted via USB or Bluetooth)

StarCom software (data transmitted via RS232)



StarLab software



StarCom software

2.2 PC Interfaces

2.2.1 Compact Juno USB Interface

Convert your laptop or desktop PC into an Ophir sensor power/energy meter

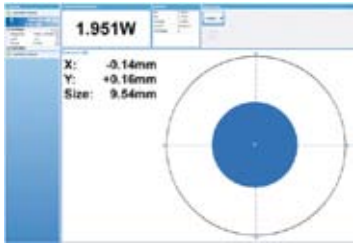
- From sensor to interface to PC - no power source needed
- Plug and play with all standard Ophir smart sensors
- Position & size measurement with BeamTrack sensors
- Record every energy pulse at up to 10kHz
- Log power and energy, average, statistics, histograms and more with included StarLab application
- LabVIEW VIs and COM Object interface
- Very compact - is just an extension of the smart plug

Smart Sensor to Juno to PC

Ophir's basic smart compact Juno module turns your PC or laptop into a full fledged Ophir laser power/energy meter.
Just install the software, plug the sensor into the Juno module and connect the Juno with a standard USB cable to the PC USB port.
Using the Juno, you can connect several sensors to the PC by using one Juno module for each sensor and, if necessary, a USB hub.

LabVIEW

Juno operating with StarLab software



Juno with BeamTrack sensor and StarLab showing beam power, position and size

Specifications

Power Measurement	
Power log period	5s to 500hr.
Energy Measurement	
Max real time data logging to PC	10,000Hz [a]
Trigger input and output	N.A.
Timing	Supports time stamp for each pulse - resolution 10µs
General	
Number of sensors supported	One sensor per unit. Can combine several units with software for display of up to 8 sensors on one PC
Compatible sensors	Supports all standard Ophir pyroelectric, thermal and photodiode sensors [b]
Power supply	Powered from USB
Dimensions	76 x 55 x 22mm
Notes:	(a) This is the data logging rate for every single point in turbo mode. Above that rate, the instrument will sample points but not log every single point (b) Not including RP sensors, PD300-CIE, BC20 and PD300-BB

Ordering Information

Item	Description	Ophir P/N
Juno	Compact module to operate one Ophir sensor from your PC USB port. Comes with software. Max repetition rate for every pulse 10kHz. Powered from PC USB port	7Z01250
Juno USB cable	Cable USB2.0 A MINI-B (1 unit supplied with Juno)	7E01217

2.2.2 Pulsar Multichannel and Triggered USB Interfaces

Convert your laptop or desktop PC into a multichannel power/energy meter

- From sensor to interface to PC
- 1,2 and 4 channel models
- Plug and play with most Ophir sensors
- Record every energy pulse at up to 25kHz
- Measure missing pulses & trigger output with external trigger
- Log power and energy, average, statistics, histograms and more with included StarLab application
- LabVIEW VIs, COM Object Interface and ActiveX software included

Smart Sensor to Pulsar to PC

Ophir's 1-4 channel Pulsar interface turns your PC or laptop into a full fledged Ophir multi-channel laser power/energy meter. Just install the software, plug the sensor into the Pulsar and the USB cable from the Pulsar to the PC USB port. With the Pulsar series, you can connect up to 4 sensors to each module, monitor each pulse at up to 25kHz and utilize external trigger.

LabVIEW

Pulsar-4 operating with StarLab software

Specifications

Power Measurement	
Power log period	5s to 500hr.
Energy Measurement	
Max real time data logging to PC	25,000Hz [a]
Trigger input and output	BNC trigger input to enable measurement of missing pulses or to select specific pulses. Can also be configured to give trigger output
Timing	Supports time stamp for each pulse - resolution 1µs
General	
Number of sensors supported	4 / 2 / 1 sensors per unit. Can combine several units with software for display of up to 8 sensors on one PC
Compatible sensors	Supports all standard Ophir pyroelectric, thermal and photodiode sensors [b]
Power supply	12V wall cube power supply plugs into jack on rear. The power supply can be ordered from your local distributor.
Dimensions	189 x 103 x 33mm
Notes:	(a) Limited by the maximum repetition rate of the sensor. At present only the PE9-F can operate up to 25000Hz (b) Not including RP sensors, PD300-CIE, BC20 and PD300-BB

Ordering Information

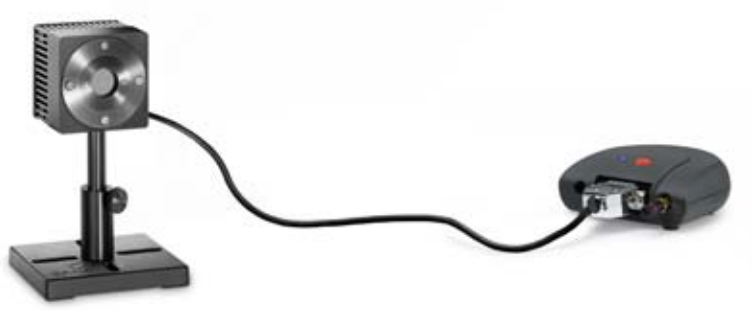
Item	Description	Ophir P/N
Pulsar-4	Module to operate up to 4 Ophir sensors from your PC USB port. Comes with software. Max repetition rate for every pulse 25kHz. Has external trigger capability. Powered from wall cube power supply (can be ordered from your local distributor).	7Z01201
Pulsar-2	Same as above but for 2 channels only	7Z01202
Pulsar-1	Same as above but for 1 channel only	7Z01203
Pulsar USB Cable	USB-A to B cable (1 unit supplied with Pulsar)	7E01202
USB Interface (USBI) legacy	Legacy smart sensor to USB interface with similar performance to Juno but larger size. Has analog output. See summary page 104 for specifications	7Z01200

2.2.3 Quasar Wireless Bluetooth Interface

Straight from your measuring sensor to your laptop or PC with no cables

- Quasar table model connects to any Ophir sensor and broadcasts to your PC
- Wireless range of 10-30 meters depending on surroundings
- Operates from rechargeable battery with typically >40 hours lifetime
- Powerful USB interface with StarLab PC application software included
- Converts your PC into a complete laser power/energy meter
- Log power and energy, average, statistics, histograms and more
- Monitor up to 7 Quasars simultaneously on one PC

Quasar Bluetooth Wireless Sensor to PC Interface



Quasar module connects to any Ophir sensor, thermal, pyroelectric or photodiode

Any PC or laptop connects to Quasar module via Bluetooth adapter and operates as a power/energy meter/data logger

Specification

Sensor Compatibility	All Ophir standard sensors, thermal, photodiode and pyroelectric
Number of Sensors on One PC	Up to 7 Quasars can operate simultaneously and be displayed at the same time on one PC
Operating Range	10-30 meters depending on surroundings when used with built in laptop Bluetooth or Ophir recommended adapter
Power	Powered by rechargeable NiMH battery. Battery life typical 40 hours, 20 hours for pyro sensors. Automatically goes into sleep mode when not connected to PC. Low batt indication. Charges from 12VDC either polarity. The charger can be ordered from your local distributor.
LED Indicator	LED indicator indicates whether connected, in standby or off
Bluetooth Standard	Bluetooth class 1. Connection to PC is transparent to user. Will work with built in laptop Bluetooth and most add on USB to Bluetooth adapters. Ophir recommended USB to Bluetooth adapter Ophir P/N 7E10039 (see table below)
Data Transfer Rate for Pyro Sensors	500Hz
Dimensions	96mm W x 95mm D x 36mm H not including antenna
Connections	15 pin D type sensor connector standard Ophir 12V charger input

Ordering Information

Item	Description	Ophir P/N
Quasar Bluetooth Interface	Module to operate one Ophir sensor from your PC via Bluetooth wireless interface. Comes with software. Max repetition rate for every pulse 500Hz. Powered from built in rechargeable battery. Comes with power supply. Bluetooth adapter required when not available on PC. See next line	7Z01300
USB to Bluetooth adapter	Adapter for PC or Laptop not equipped with built in Bluetooth. This adapter is tested and recommended by Ophir. Quasar is not guaranteed to work with all other adapters on the market	7E10039
Battery Pack for Quasar	Replacement battery pack for Quasar	7E14007

Summary of Computer Options for Ophir Meters and Interfaces

Communications

With Ophir RS232, USB, Bluetooth and GPIB communication options you can transfer data from the sensor to the PC in real time or offline. You can also control your Ophir power meter from the PC.

- USB standard on Nova II, Vega power meters and Juno, Pulsar and USBI PC interfaces
- Bluetooth wireless on the Quasar interface
- RS232 standard with the Laserstar, Nova II and Vega, optional on the Nova
- GPIB optional with the Laserstar

Ophir Power Meter and Interface Specifications

Model	Nova	Laserstar	Nova II / Vega	StarLite [c]	Pulsar-1, 2 or 4	Juno	USB interface (legacy)	Quasar Bluetooth
Communication Method	RS232	RS232 / GPIB	USB / RS232	N.A	USB	USB	USB	Bluetooth
Power Measurement								
Power log period	5s to 24hr.	12s to 600hr.	12s to 600hr.	N.A	5s to 500hr.	5s to 500hr.	5s to 500hr.	5s to 500hr.
Max points stored onboard	300	5400	Nova II 5400 Vega 27000	N.A	N.A	N.A	N.A	N.A
Max points direct on PC	unlimited	unlimited	unlimited	N.A	unlimited	unlimited	unlimited	unlimited
Analog output	1V F.S.	1V F.S.	1V, 2V. 5V, 10V F.S.	1V F.S.	N.A	N.A	1V F.S.	N.A
Energy Measurement								
Max real time data logging to PC	>10Hz	>30Hz RS232 >1500Hz GPIB[a]	>2000Hz USB[a] >30Hz RS232	N.A	25,000Hz [a]	10,000Hz [a]	2000Hz [a]	500Hz
Max onboard data logging rate	>10Hz	>1500Hz [a]	4000Hz [a]	N.A	N.A	N.A	N.A	N.A
Data transfer rate of a data file from instrument to PC	~50 points/s	~500 points/s	~500 points/s	N.A	N.A	N.A	N.A	N.A
Max points stored onboard	1000	54,000	Nova II 60,000 Vega 250,000	N.A	N.A	N.A	N.A	N.A
Trigger input and output	N.A	N.A	N.A	N.A	BNC trigger input to enable measurement of missing pulses. Can also be configured to give trigger output.	N.A	N.A	N.A
Timing - time stamp for each pulse	N.A	N.A	N.A	N.A	resolution 1µs	resolution 10µs	resolution 50ms	resolution 10ms
General								
Automation Interface	no	no	yes	N.A	yes	yes	yes	no
LabVIEW VIs	yes	yes	yes	N.A	yes	yes	yes	no
Maximum baud rate	19200 [b]	38400	38400	N.A	N.A.	N.A.	N.A.	N.A.
PC file format	Text files, spreadsheet compatible ASCII			N.A	Text files, spreadsheet compatible ASCII			
Number of sensors supported	One sensor per unit.	One sensor per unit for single channel mode. Two sensors per unit for dual channel mode.	One sensor per unit. Can combine several units with software for display of up to 8 sensors on one PC	One sensor per unit	4 / 2 / 1 sensors per unit. Can combine several units with software for display of up to 8 sensors on one PC	One sensor per unit. Can combine several units with software for display of up to 8 sensors on one PC	One sensor per unit. Can combine several units with software for display of up to 8 sensors on one PC	One sensor per unit. Can combine several units with software for display of up to 7 Quasars on one PC
Compatible sensors	Supports most Ophir pyroelectric, thermal and photodiode sensors							
Power supply	Powered from internal rechargeable battery power supply	Powered from internal rechargeable battery power supply	Powered from internal rechargeable battery power supply	Powered from internal rechargeable battery power supply	12V wall cube plugs into jack on rear	Powered from USB	Powered from USB	Powered from internal rechargeable battery power supply
Dimensions	205 x 95 x 39mm	228 x 195 x 54mm	208 x 117 x 40mm	213 x 113 x 40mm	189 x 103 x 33mm	76 x 55 x 22mm	155 x 90 x 34mm	96 x 95 x 36mm

Notes:
(a) The above refers to the rate for logging every single point in turbo mode. Above that rate, the instrument will sample points but not log every single point.
(b) For pyroelectric sensors, maximum guaranteed baud rate is 9600.
(c) The low cost StarLite power meter does not have a PC Interface support or onboard logging. For customers that need these features, please consider one of our other offerings

2.3 Software Solutions

2.3.1 StarLab

StarLab turns your PC into a laser power/energy multi-channel station

Extensive Graphic Display of Data

- Line Plot, Histogram, Bar chart, Simulated Analog Needle
- Multiple data sets on one graph or separate graphs on the same screen

Advanced Measurement Processing

- Power/Energy Density, Scale Factor, Normalize against a reference
- Multi-channel comparisons
- User defined mathematical equations: channels A/B, (A-B)/C etc.
- Position & size measurement with BeamTrack sensors

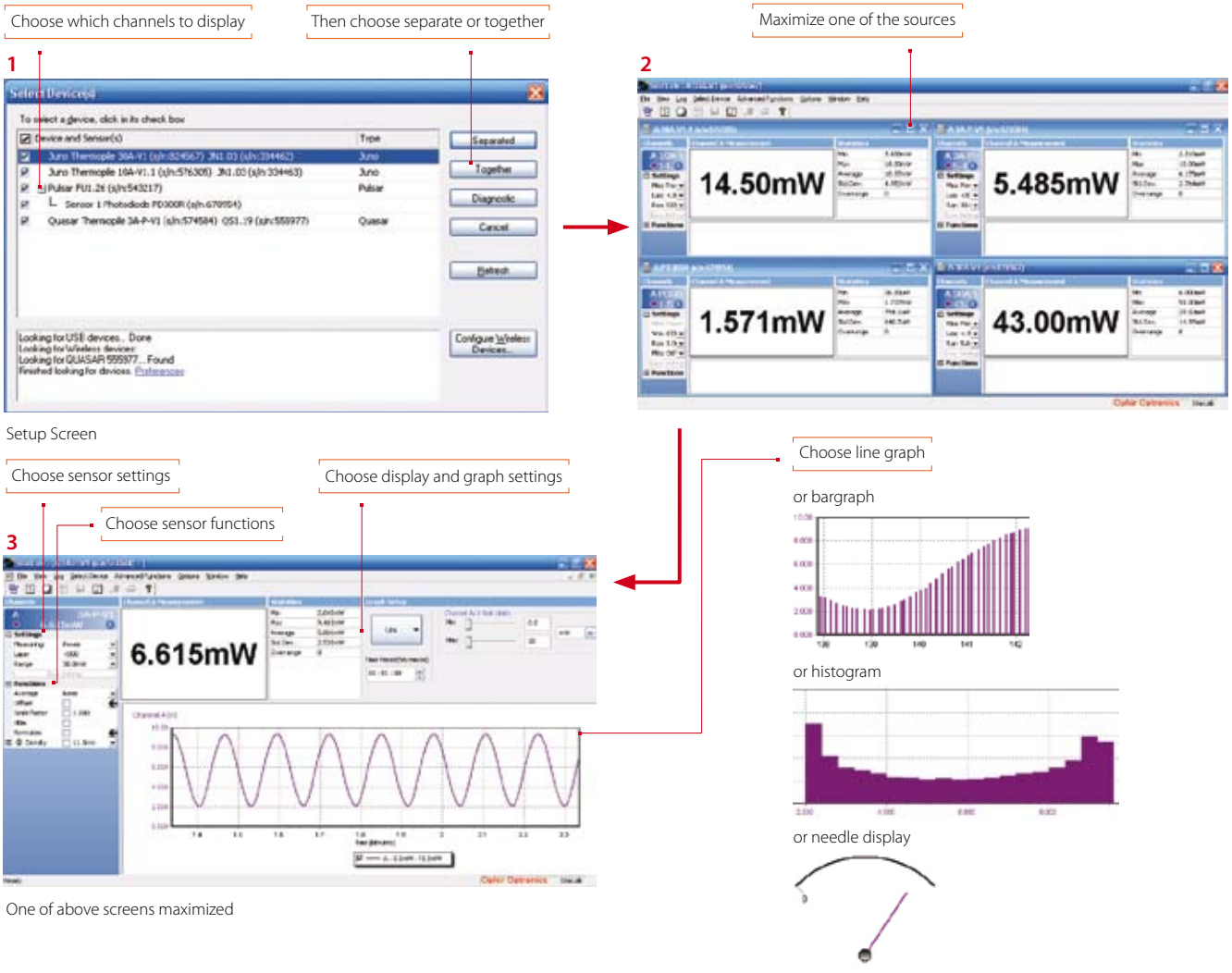
Data Logging for Future Review

- Can be displayed graphically or saved in text format
- Easily exported to an Excel spreadsheet

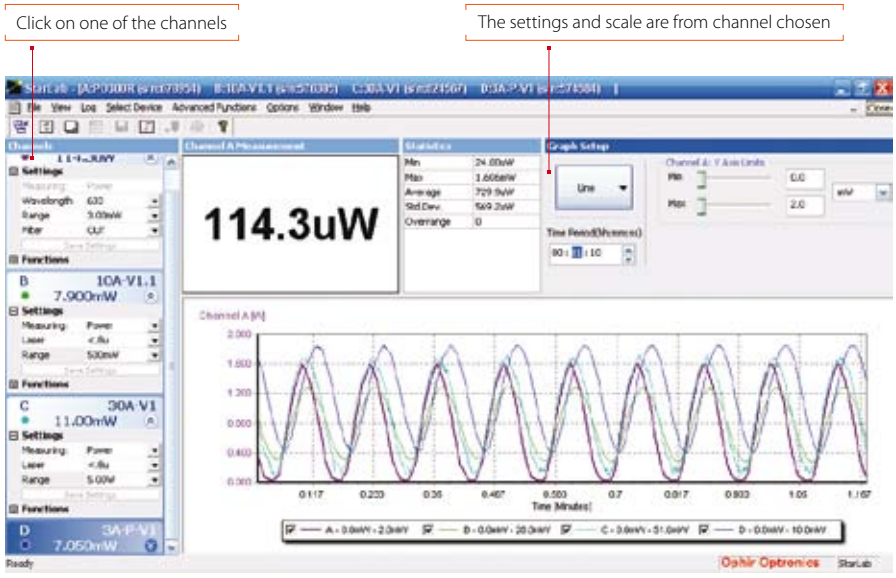
Fully supports Vega, Nova-II, Pulsar, Juno, USBI and Quasar devices with all standard Ophir sensors

Flexible Display Options with StarLab

Each sensor displayed separately



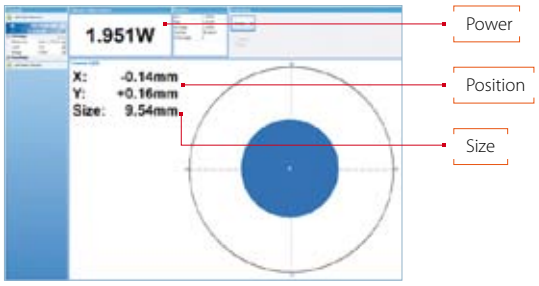
Multiple sensors displayed together



Here multi line graph display has been chosen

Here multi line histogram display has been chosen

BeamTrack Power/Position/Size sensor



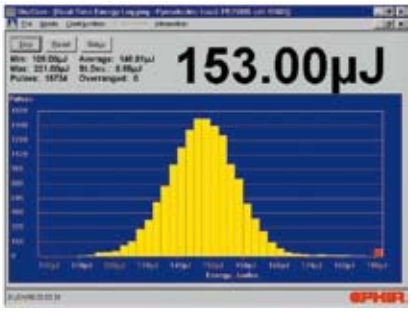
Here a BeamTrack position and size graph is shown

2.3.2 StarCom

This software is supplied with the Nova II, Laserstar, Vega and Nova with RS232 option. It allows you to measure, analyze and record power and energy from any Ophir sensor.
You can log the data from each sensor simultaneously to file.

Plot of ratio of energy B/A vs. energy A

Plot of power vs. time



Histogram plot of energy distribution

System Integrator Solutions

Besides their use as stand-alone, fully featured laser power/energy meters, Ophir devices are easily incorporated into larger end-user applications. This allows system integrators to leverage Ophir's excellence in measurement capabilities with legacy analysis packages.

Communication Protocols

All Ophir devices support one or two forms of communication with the PC.

Device	RS232	USB	GPIB	Bluetooth
Pulsar		●		
Vega	●	●		
Nova-II	●	●		
USB Interface		●		
Nova	●			
LaserStar	●		●	
Quasar				●
Juno		●		

RS232

RS232 communication is the simplest to integrate into your OEM application. Integrated Development Environments (IDE's) such as Microsoft Visual Studio provide functions and methods for accessing the PC's com port.

The following is all that you need to get your RS232 applications up and running

- Appendix A5 of the StarCom User Manual (P/N 1J06025) contains an alphabetical listing and detailed description of all commands available with the Nova, Nova-II, Vega and LaserStar devices.

- Appendix A4 of the StarCom User Manual (P/N 1J06025) gives an example of polling the Nova device for measurements. This was written in VB6.
- An appropriate RS232 assembly.
- Nova RS232 Assembly (P/N 78105) for use with the Nova device.
- Nova II / Vega RS232 cable (P/N 7E01206) for use with the Nova-II and Vega devices (included with the Nova II / Vega).
- LaserStar RS232 cable (P/N 1E01121, included with the LaserStar).

GPIB

Besides RS232, the LaserStar can also communicate via GPIB (IEEE 488.1). Using the SDK supplied by the vendor of your GPIB controller hardware, a LaserStar IEEE cable (P/N 78300) and the StarCom User Manual, you can integrate the LaserStar into your GPIB solution.

USB

Ophir provides a common interface for communication and control of all of our USB speaking devices. OphirLMMeasurement is a COM object that is included as part of the StarLab installation (StarLab 2.10 and higher) that allows the system integrator to take control of the Juno, Nova-II, Pulsar, USBI and Vega devices; integrating them into his in-house measurement and analysis package.

For communication via USB, device drivers and additional support software must be installed on your PC. These components are installed as part of the StarLab application's installation process.

System Integrators will need the following components:

- OphirLMMeasurement COM Object.doc. lists and describes the methods and events available for configuring, controlling and uploading measurements from Ophir devices.
- OphirLMMeasurement.dll. COM object component developed and supplied by Ophir for communication with the Juno, Nova-II, Pulsar, USBI and Vega devices. The COM object is registered when the application is installed.
  OphirLMMeasurement COM Object.doc describes how to register it on another PC where the Ophir application has not been installed.
- Standard USB cable for use with the Pulsar and USBI devices (included).
- Standard mini-B USB cable for use with the Juno device (included).
- Nova II / Vega USB cable (P/N 7E01205) for use with the Nova-II and Vega devices (included with the Nova II / Vega).

Ophir provides example projects of COM Object clients in VC#, VB.NET and LabVIEW. These are found in the Automation Examples subdirectory of our StarLab PC Application.

Note: The OphirFastX (for Pulsar devices) as well as the OphirUsbX (for Nova-II, USBI and Vega devices) ActiveX packages are included with the StarLab installation so as to not disrupt legacy OEM installations by customers. However, new features will not be added to them. For new designs, we highly recommend using OphirLMMeasurement.

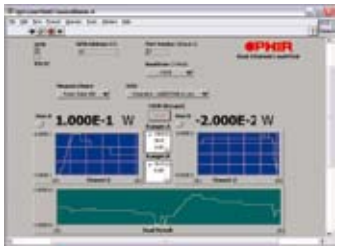
2.3.3 LabVIEW Solutions

Ophir has long recognized the growing LabVIEW community of developers. For over 10 years, we have been providing LabVIEW libraries for all of our devices. These are full open-source applications that can be used as is or tailored by the LabVIEW programmer to his specific needs.

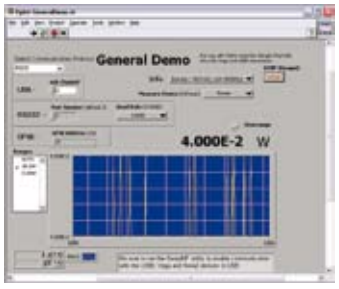
These starter applications are basic software only that allows the LabVIEW programmer to experiment freely to fully feel the strength of our devices' respective command sets.
These applications contain VIs (Virtual Instruments) to control the instrument. You can combine VIs to create successively larger and more versatile larger VIs by simply connecting them together. Users can create sophisticated, custom applications in minutes. In most cases, applications can be built and tested even before the instrument even arrives. The versatility of these tools is limitless.

All of our LabVIEW libraries can be downloaded from our web site: www.ophiropt.com

VI Libraries
Ophnova.llb
Library supplied for use with the Nova. Communication is in RS232 and is based on NI-VISA.



OphIstrd.llb
Library supplied for use with the Dual-Channel LaserStar. Communication can be set to RS232 or GPIB and is based on NI-VISA.



OphInstr.llb
This library can be configured to work with the Nova-II, Vega, USB Interface or Single-Channel LaserStar devices. It can also work with the Juno with a Thermopile or Photodiode sensors. It can be set to RS232, USB or GPIB. It is based on NI-VISA for all 3 communication protocols. Therefore to work with it in USB, first run the **SwapINF** utility that we provide to configure your PC to replace the USB drivers supplied by Ophir with drivers supplied by National Instruments.

LabVIEW COM Demo.llb
Library supplied for use with all of our USB speaking devices (Juno, Nova-II, Pulsar, USBI, Vega). Makes use of our COM object. Included with our StarLab application.

2.4 OEM Power Meter Solutions

2.4.1 Examples of Custom OEM Power/Energy Meter Solutions

In addition to the standard products described above, Ophir has accumulated over 25 years experience in developing products which are tailored to precise physical configurations provided by the OEM customer. These products include special display software options, OEM power/energy meter board sets and much more. A number of these special OEM products are shown below.

Moving LED Indicator

Thermal OEM sensor with special LED indicator where LEDs light up in proportion to power reading. When power is over maximum, red LEDs light up.

Rack Mount Laserstar Meter

OEM Laserstar meter for rack mount with input from front, outputs and shielded metal case on rear.

Nova OEM Board Set

The Nova meter can be purchased as a board set for installation in the host system. Communication with the unit is either via RS232 or via the set's own buttons; output can be RS232 digital or an analog voltage.

Ordering Information:

The products shown above are examples of OEM solutions developed for specific customer applications. Please consult with your Ophir representative who will be happy to help you with any requirements you may have.

Laser Beam Analysis

3.1 Choosing a Beam Profiler

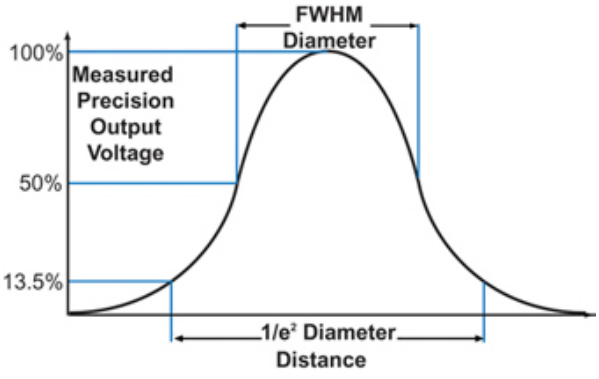
A laser beam profiler will increase your chance of success anytime you wish to design or apply a laser or when you find your laser system is no longer meeting specifications. You would never think of trying to build a mechanical part without a micrometer. So why attempt to build lasers or laser systems with only a power meter? You will produce the desired results more quickly if you can measure basic things like beam width or size, beam profile and power.

We believe as Lord Kelvin said: "You cannot improve it if you cannot measure it".

3.1.1 Four Basic Questions

When choosing a laser beam profiler there are a plethora of choices to do the job, including CCD and CMOS cameras, scanning slit sensors, InGaAs and pyroelectric cameras, pinhole, and knife edge sensors to mention some. How does one decide which is the proper solution for one's application and from which company to obtain the profiler system? When making the selection there are four basic questions about the laser application that one must answer.

Wavelength?



The first question is: *What wavelength(s) do you intend to measure?* The answer to this question determines the type of detector needed, and what the most cost effective approach may be. For the UV and visible wavelength range from <193nm up to the very near infrared at around 1300nm, silicon detectors have the response to make these measurements. The largest number of cost effective solutions exist for these wavelengths including CCD cameras and silicon detector-equipped scanning aperture systems. Which of these is the best will be determined by the answers to the other three questions.
For the near infrared, from 800 to 1700nm, the choices become less abundant. In the lower end of this range from 800–1300nm the CCD cameras may still work, but InGaAs arrays become necessary above 1300nm. These are quite expensive; four to five times the cost of the silicon CCDs. Scanning slit systems equipped with germanium detectors are still quite reasonably priced, within a few hundred dollars of their silicon-equipped cousins. At the mid and far infrared wavelengths the pyroelectric cameras and scanning slits sensors with pyroelectric detectors provide viable alternatives, again the best approach being determined by the answers to the subsequent questions.

Beam Size?

The second question is: *What beam width or spot size do you wish to measure?* This question can also impact the profiler type choices. Arrays are limited by the size of their pixels. At the current state-of-the-art pixels are at best around 4µm for silicon arrays, and considerably larger, 30um to 80um with InGaAs and pyroelectric cameras. This means that a UV-NIR beam should be larger than 50µm or roughly 10 pixels in diameter to ensure that enough pixels are utilized to make an accurate measurement. Beams with spot sizes smaller than 50um can be optically magnified or expanded to be measured with a camera. InGaAs camera pixels are around 30µm, limiting the minimum measurable beam size to 300µm; pyroelectric array pixels are even larger at 80µm, meaning the beams need to be at least 0.8mm to yield accurate results. Scanning slit profilers can measure with better than 2% accuracy beams that are four times the slit width or larger, putting the minimum beam sizes at around 8µm without magnification. Those investigators who want to measure their beams directly without additional optics could find this to be an advantage.

Power?

The third question is: *What is the power of the beam?* This determines the need for attenuation, and/or beam splitting, as well as the detector type. Array detectors, such as silicon CCD, CMOS, InGaAs and Pyroelectric cameras will usually need attenuation when measuring lasers. Scanning slit type profilers can measure many beams directly without any attenuation, due to the natural attenuation of the slit itself. Detector arrays and knife-edge profilers, by their nature, will allow the entire beam to impact the detector at some point in the measurement, leading to detector saturation unless the beam is appropriately attenuated. Lasers of any wavelength with CW powers above 100mW can be measured with the pyroelectric detector-equipped scanning slit profiler, making it the easiest profiler for many applications. Scanning slit profilers can directly measure up to kilowatts of laser power, depending on the spot size or power density.

CW or Pulsed?

The final question is: *Is the laser continuous wave (CW) or pulsed?* Lasers that operate pulsed at repetition rates less than ~10 kHz are best profiled with an array. Scanning apertures simply cannot make these measurements effectively in "real time". CW and pulsed beams with repetition rates above ~10 kHz can be measured with scanning slits if the combination of the repetition rate and the beam size are sufficient to have enough laser pulses during the transit time of the slits through the beam to obtain a good profile. Knife-edge profilers are only able to measure CW beams. Pulsed beams have other considerations when selecting a beam profiling instrument, particularly pulse-to-pulse repeatability, and pulse-energy damage thresholds of the slit material or in the case of array detectors, beam sampling optics.

3.1.2 One More Question

Besides these four questions about the physical nature of the laser to be measured, there is one more that needs to be asked: How accurate does the measurement need to be? Not all profilers or profiler companies are equal in this regard. Properly designed, maintained and calibrated camera and based slit profilers can provide nanometer precision for both beam width and beam position (centroid) measurements.

A state-of-the-art CCD array with 4µm pixels can provide ±2% beam width accuracy for beams larger than 50µm. Accuracy for smaller beams may be worse due to the effects of insufficient resolution or pixilation. In addition, the effects of attenuation optics, noise and proper baseline zeroing or offset compensation can have dramatic impact on the accuracy of the measurement. Cameras that are not designed specifically for profiling may be much worse due to the presence of a cover glass and/or IR cut-off filter covering the array. These optical elements must be removed for laser profiling to prevent interference fringes or distortion of the beam being tested. Camera arrays provide a true two-dimensional picture of the beam and will show fine structure and hot and cold spots, which a slit will integrate out. Some applications do not require a map of the laser power distribution with in the spot. Spot size and spot location are sufficient. Other applications require that a careful mapping of the complete mode structure is made. These applications require 2D, array based sensors. The accuracy requirement is a question of what the data is to be used for. Accurate collimation or focus control requires the highest beam size accuracy. Checking the laser for hot spots, uniformity or beam shape dictates that the 2D sensor is employed and is as important as absolute size measurement accuracy.

How and where a profiler is to be used is also an important consideration in the equation. Profilers used by research and development scientists are often specialized. Ease-of-use and high throughput may be of no consequence if the purpose is to characterize specific optical systems that are well understood by the investigator. On the other hand, when a profiler needs to be used on the factory floor for quality assurance of the manufacturing process, ease-of-use, high throughput, and reproducibility become paramount. In this case the profiler requiring the least "fiddling" is generally the best fit. Here there is a competition between the intuitive and the ease-of-use. Some people find the 2-dimensional camera array to be the most intuitive, because they can relate to the idea of "taking a picture" of the laser beam; X-Y scanning slits may seem less intuitive. For any process that uses or works with CW or high frequency pulsed lasers the scanning slit will have the advantage of measuring the beam directly, possibly even at its focus point, without additional attenuation optics. The dynamic range of these systems is also broad enough to measure both the focused and the unfocused beam without changing the level of attenuation. Camera arrays, on the other hand will require attenuation adjustment.

Conversely, if the important aspect of the measurement is the two-dimensional image of the beam, or if the laser is pulsed at a low repetition rate, the array will be the solution; even if it means attenuation optics.

Also, many factory applications may want to 'embed' the beam profiler into a manufacturing cell or a piece of automation so the measurements and possibly pass/fail results are completed automatic. If so look for a system that has this ability. Most often the capability to interface the profiler into the overall system through a LabView, Excel or .NET interface is available.

So Camera or scanning slit, whichever is selected the user must first determine the laser beam measurement environment and what information about the beam profile is most important to the success of the application. Ease of use and absolute spot size favors the scanning slit system while knowing about the hot and cold spots or the image of the beam under test, or any low repetition pulsed laser, requires a camera based beam profiling system. The assistance of knowledgeable product specialists is required to provide analysis of the measurement requirements of your laser application as well as to describe the features and benefits of available products.

Camera-based Beam Profiler

Slit-based Beam Profiler

3.1.3 User Guide for Choosing the Optimum Beam Profiling System

Laser Wavelength	Power			Minimum Beam Size				
	<100mW	100mW-100W	>100W	<20µm	>20 <50µm	>50µm	>500µm	>1mm
UV-Vis	NS-Si	NS-Pyro	HP-NS	NS-Si/3.5/1.8	NS-Si/9/5	NS-Si/9/5	NS-Si /9/5	NS-Si /9/5
	SP620	SP620	NS-Pyro		NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5
			SP620			SP620	SP620	SP620
NIR 1000-1100nm	SP620	NS-Pyro	HP-NS	NS-Ge/3.5/1.8	NS-Ge/9/5	NS-Ge/9/5	NS-Ge/9/5	NS-Ge/9/5
	NS-Ge	SP620	NS-Pyro		NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5
			SP620			SP620	SP620/ SP503	
							Pyrocam	
Telecom and Eye-Safe 1100-1800nm	NS-Ge	NS-Pyro	HP-NS	NS-Ge/3.5/1.8	NS-Ge/9/5	NS-Ge/9/5	NS-Ge/9/5	NS-Ge/9/5
			NS-Pyro		NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5
						XEVA	XEVA	XEVA
							Pyrocam	Pyrocam
1500-1600nm	NS-Ge	NS-Ge	NS-Ge	NS-Ge/3.5/1.8	NS-Ge/9/5	NS-Ge/9/5	Pyrocam	NS-Ge/9/5
	SP 620-1550	SP 620-1550	SP 620-1550			SP 620-1550	XEVA	SP 620-1550
								XEVA
MIR & FIR	Pyrocam	NS-Pyro	HP-NS	Pyrocam w/ Beam Expansion	NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5
		Pyrocam	NS-Pyro				Pyrocam	Pyrocam
			Pyrocam					
			ModeCheck					

Abbreviations:

FIR	Far Infrared	**NIR**	Near Infrared
Ge	Germanium	**Si**	Silicon
HP	High Power	**SP**	Indicates camera profiler
MIR	Mid-Infrared	**NS**	NanoScan
UV-Vis	Ultraviolet - Visible		

Laser Wavelength	Minimum Beam Size		CW or Pulsed			Customer Priority				
	>5mm	>10mm	CW	Pulsed <1kHz	Pulsed >1kHz	Price	2D/3D	No optics	Speed	Ease of use
UV-Vis	NS-Si /9/5	NS-Si /25/25	NS	SP620	SP620	SP620	SP620	NS	NS	NS
	NS-Pyro/20/25	NS-Pyro/20/25	SP620		NS					
	SP620	L11059								
NIR 1000-1100nm	NS-Ge/12/25		NS	SP620	SP620	SP620	SP620	NS	NS	NS
	NS-Pyro/20/25	NS-Pyro/20/25	SP620		NS					
		L11059								
Telecom and Eye-Safe 1100-1800nm	NS-Ge/12/25		NS	XEVA	XEVA	NS	XEVA	NS	NS	NS
	NS-Pyro/20/25	NS-Pyro/20/25			NS		Pyrocam			
	Pyrocam									
1500-1600nm	NS-Ge/12/25	NS-Pyro/20/25			NS					
	SP 620-1550		XEVA	XEVA	XEVA	SP 620-1550	SP 620-1550	NS	NS	NS
MIR & FIR	NS-Pyro/20/25	NS-Pyro/20/25	NS	Pyrocam	NS	NS	Pyrocam	NS	NS	NS
	Pyrocam		Pyrocam		Pyrocam					

Abbreviations:

FIR	Far Infrared
Ge	Germanium
HP	High Power
MIR	Mid-Infrared
UV-Vis	Ultraviolet - Visible
NIR	Near Infrared
Si	Silicon
SP	Indicates camera profiler
NS	NanoScan

3.1.4 Benefits of Beam Profiling

You can get more out of your laser

- Figure 1 shows an industrial Nd: YAG laser, near Gaussian beam, with 100 Watts output power and 1.5kW/cm^2 power density. Figure 2 is the same Nd: YAG beam at greater power, 170 Watts, but it split into 2 peaks producing only 1.3kW/cm^2 power density. The power density of the beam decreased 13% instead of increasing by the 70% expected. Without measuring the beam profile and beam width, you would not know what happened to your power density, and why the performance did not improve.

Laser cavities become misaligned

- Figures 3 & 4 are beam profiles of CO_2 lasers used for ceramic wafer scribing in the same shop. The second laser with the highly structured beam produced mostly scrap parts, until the laser cavity was aligned.

Off axis delivery optics

- Figures 5 & 6 show an industrial Nd:YAG laser with misaligned turning mirror, before and after adjustment.

Alignment of devices to lenses

- Figures 7 & 8 show beam profiles during alignment of a collimating lens to a laser diode. The first profile shows poor alignment of the lens to the diode, which can easily be improved when seeing the profile in real time.

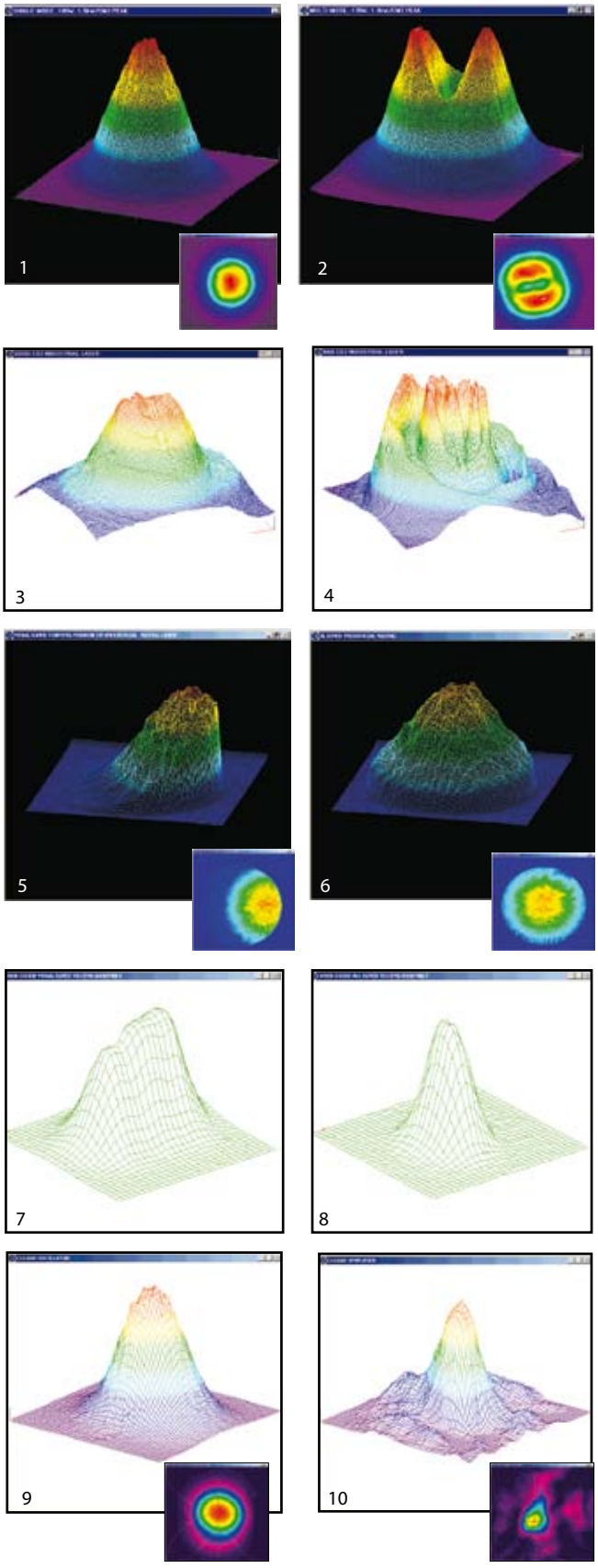
Laser amplifier tuning

- Figures 9 & 10 show a Cr:LiSAF femtosecond laser oscillator beam with a near Gaussian output, and what happens to the oscillator beam with poor input alignment.

All these examples illustrate the need for beam monitoring

- Measurement of the beam profile is needed to know if problems exist, and the profile must be seen to make corrections
- Most laser processes can be improved
- Scientific experiments can be more accurate
- Commercial instruments can be better aligned
- Military devices can have greater effectiveness
- Industrial processing produces less scrap
- Medical applications are more precise

Just knowing the beam profile can make the difference between success and failure of a process.



3.2 Introduction to Camera-Based Profilers

Beam Attenuating Accessories

A camera-based beam profiler system consists of a camera, profiler software and a beam attenuation accessory. Spiricon offers the broadest range of cameras in the market to cope with wavelengths from 13nm, extreme UV, to 3000 µm, in the long infrared. Both USB and FireWire interfaces are available for most wavelength ranges providing flexibility for either laptop or desktop computers.

BeamGage®, the profiling software, comes in three versions: Standard, Professional and Enterprise. Each builds off of the next adding additional capability and flexibility needed for adapting to almost any configuration requirement.
Spiricon also has the most extensive array of accessories for beam profiling. There are components for attenuating, filtering, beamsplitting, magnifying, reducing and wavelength conversion. There are components for wavelengths from the deep UV to CO2 wavelengths. Most of the components are modular so they can be mixed and matched with each other to solve almost any beam profiling requirement needed.

Acquisition and Analysis Software

The BeamGage software is written specifically for Microsoft Windows operating systems and takes full advantage of the ribbon-base, multi-window environment. The software performs rigorous data analyses on the same parameters, in accordance with the ISO standards, providing quantitative measurement of numerous beam spatial characteristics. Pass/Fail limit analysis for each of these parameters can be also applied.

- ISO Standard Beam Parameters
- Dslit, Denergy, D4σ
- Centroid and Peak location
- Major and Minor axes
- Ellipticity, Eccentricity
- Beam Rotation
- Gaussian Fit
- Flat-top analysis / Uniformity
- Divergence
- Pointing stability

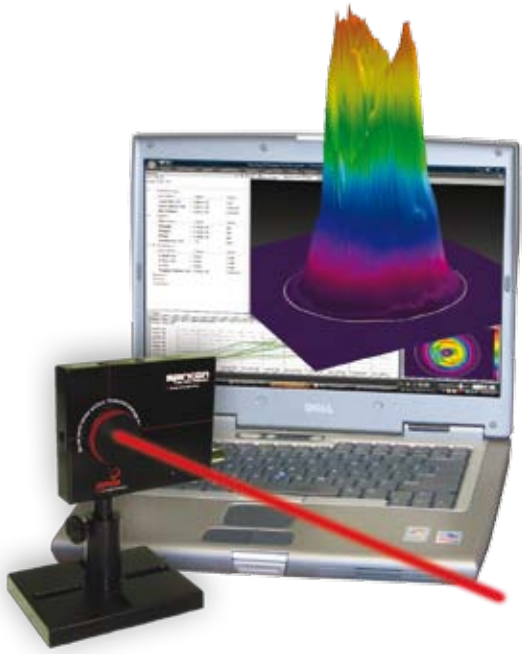
For data display and visualization, the user can arrange and size multiple windows as required. These may contain, for example, live video, 2D Topographic and 3D views, calculated beam parameters and summary statistics in tabular form with Pass/Fail limit analysis, and graphical strip chart time displays with summary statistics and overlays. Custom configured instrument screens with multiple views can be saved as configuration files for repeated use. Data can be exported to spreadsheets, math, process/ instrumentation and statistical analysis programs, and control programs by logging to files or COM ports, or by sharing using LabView or ActiveX Automation.

- Video Dual Aperture Profiles
- Beam Statistics
- 3D Profile View
- 2D Topographic View
- Time Statistics Charts
- Pointing / Targeting
- Hide measurements and features not in use for user simplicity
- Notes

3.2.1 BeamGage

See your beam as never before

3.2.1.1 BeamGage®-Standard Version



- Extensive set of ISO quantitative measurements
- Patented Ultracal™ algorithm for highest accuracy measurements in the industry
- Customizable user interface for 'ease of use
- Auto-setup and Auto-exposure capabilities for fast set-up and optimized accuracy
- Statistical analysis on all calculated results displayed in real time
- New BeamMaker® beam simulator for algorithm self-validation

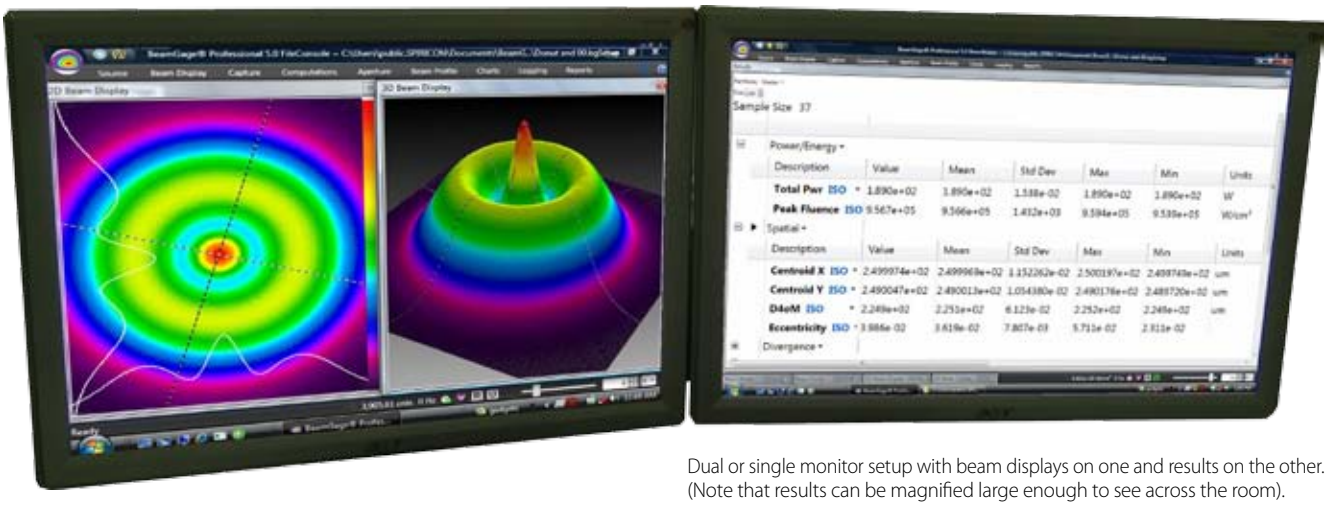
The performance of today's laser systems can strongly affect the success of demanding, modern laser applications.
The beam's size, shape, uniformity or approximation to the expected power distribution, as well as its divergence and mode content can make or break an application. Accurate knowledge of these parameters is essential to the success of any laser-based endeavor. As laser applications push the boundaries of laser performance it is becoming more critical to understand the operating criteria.

For over thirty years Ophir-Spiricon has developed instruments to accurately measure critical laser parameters. Our LBA and BeamStar software have led the way. Now with the introduction of BeamGage, Ophir-Spiricon offers the first "new from the ground up" beam profile analysis instrument the industry has experienced in over 10 years.

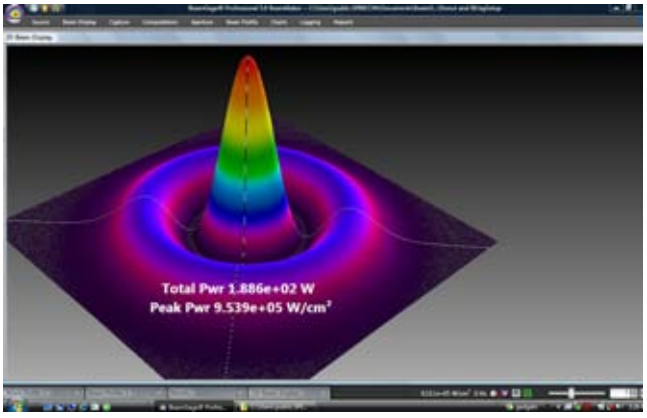
BeamGage includes all of the accuracy and ISO approved quantitative results that made our LBA software so successful. BeamGage also brings the ease-of-use that has made our BeamStar software so popular. Our patented UltraCal algorithm, guarantees the data baseline or "zero-reference point" is accurate to 1/10 of a digital count on a pixel-by-pixel basis. ISO 11146 requires that a baseline correction algorithm be used to improve the accuracy of beam width measurements. UltraCal has been enhanced in BeamGage to assure that accurate spatial measurements are now more quickly available.

See Your Beam As Never Before:

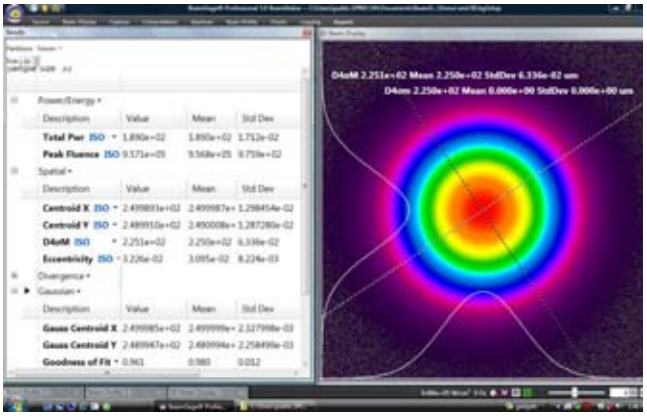
The Graphical User Interface (GUI) of BeamGage is new. Dockable and floatable windows plus concealable ribbon tool bars empowers the BeamGage user to make the most of a small laptop display or a large, multi-monitor desktop PC.



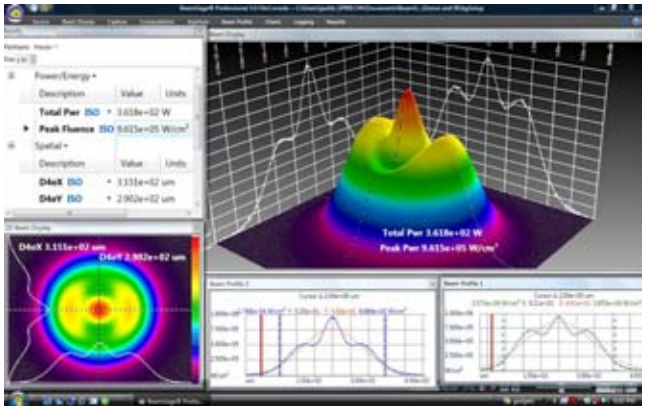
Dual or single monitor setup with beam displays on one and results on the other. (Note that results can be magnified large enough to see across the room).



Beam only (Note results overlaid on beam profile).



Beam plus results



Multiple beam and results windows.
(Note quantified profile results on 3D display & quantified 2D slices).

- 3D displays Rotate & Tilt. All displays Pan, Zoom, Translate & Z axis Zoom.

Measure Your Beam As Never Before:

Ultracal: Essential, or no big deal?

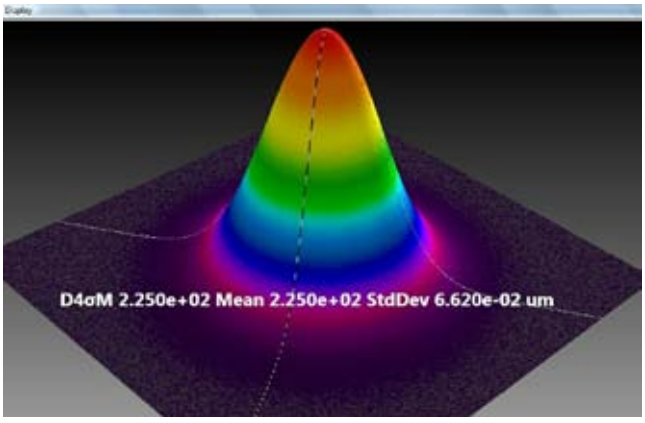
If you want accurate beam measurements, you want Ultracal.

What is Ultracal?

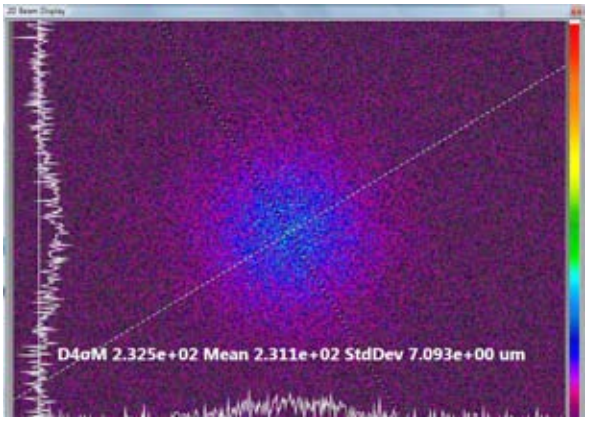
Our patented, baseline correction algorithm helped establish the ISO 11146-3 standard for beam measurement accuracy. The problems with cameras used in beam profile measurements are: a) baseline, or zero, of the cameras drift with time temperature, and b) include random noise. Ultracal is the only beam profiler algorithm that sets the baseline to "zero", and, in the center of the noise. (Competitive products use other less sophisticated algorithms that perform a baseline subtraction, but truncate the noise below the "zero" of the baseline. This leaves only a "positive" component, which adds a net value to all beam measurements).

Try the following on any other beam profiler product to see the inherent error if you don't use Ultracal.

1. Measure a beam with full intensity on the profiler camera.
2. Insert a ND2 filter (100X attenuation) into the beam and measure it again.
3. Compare the results.
4. The Standard Deviation below is about 3%, which is phenomenal compared to the 100% or more of any beam profiler without Ultracal.



Beam at full intensity, Width 225µm, Std Dev 0.06µm



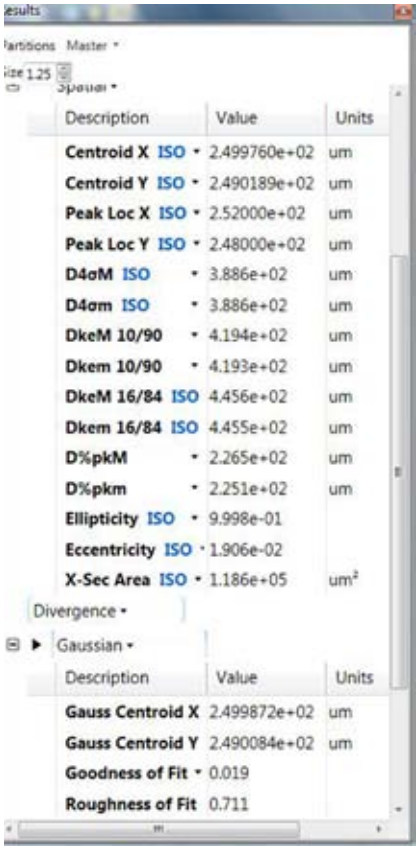
Beam attenuated 100X (displayed here in 2D at 16X magnitude zoom), Width 231µm, Std Dev 7µm

Adding the use of Automatic Aperture improves the accuracy to 1%. (The conditions of this measurement is a camera with a 50dB SNR).

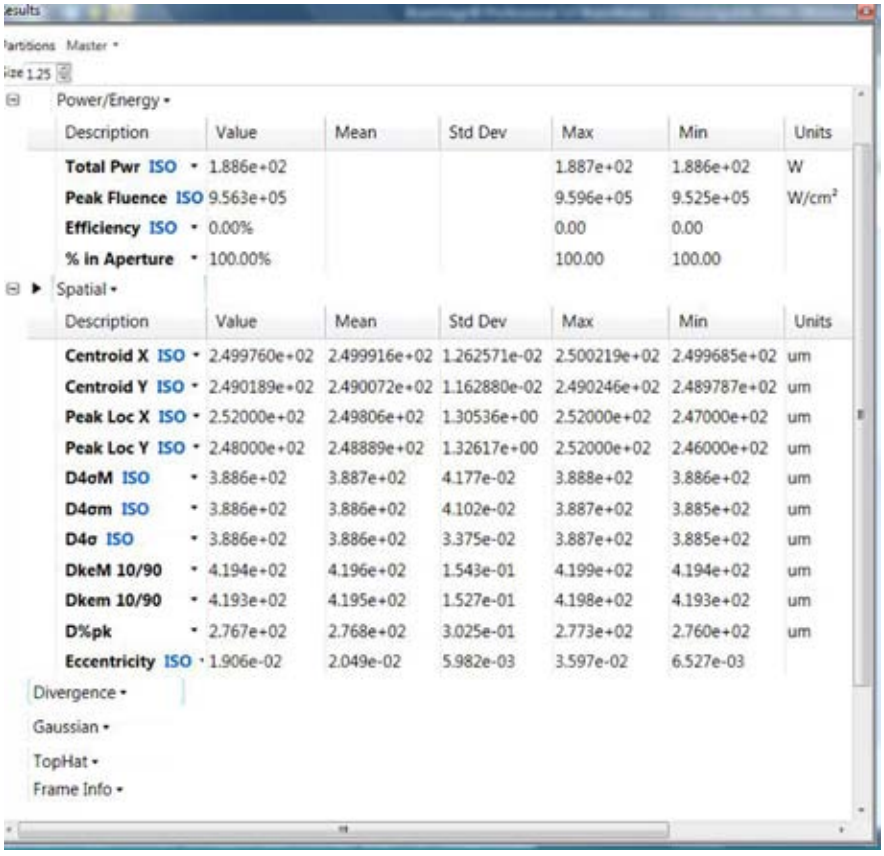
5. You normally don't make measurements at such a low intensity. But occasionally you may have a drop in intensity of your beam and don't want to have to adjust the attenuation. Or, you may occasionally have a very small beam of only a few tens of pixels. In both of these cases, Ultracal becomes essential in obtaining accurate measurements.

Beam Measurements and Statistics

BeamGage allows you to configure as many measurements as needed to support your work, and comes standard with over 55 separate measurement choices. To distinguish between calculations that are based on ISO standards and those that are not, a graphical ISO logo is displayed next to appropriate measurements. You can also choose to perform statistical calculations on any parameter in the list.


Description Value Units
Centroid X ISO 2.499760e+02 um
Centroid Y ISO 2.490189e+02 um
Peak Loc X ISO 2.52000e+02 um
Peak Loc Y ISO 2.48000e+02 um
D4σM ISO 3.886e+02 um
D4σm ISO 3.886e+02 um
DkeM 10/90 4.194e+02 um
Dkem 10/90 4.193e+02 um
DkeM 16/84 ISO 4.456e+02 um
Dkem 16/84 ISO 4.455e+02 um
D%pkM 2.265e+02 um
D%pkm 2.251e+02 um
Ellipticity ISO 9.998e-01
Eccentricity ISO 1.906e-02
X-Sec Area ISO 1.186e+05 um²
Divergence
Gaussian
Description Value Units
Gauss Centroid X 2.499872e+02 um
Gauss Centroid Y 2.490084e+02 um
Goodness of Fit 0.019
Roughness of Fit 0.711

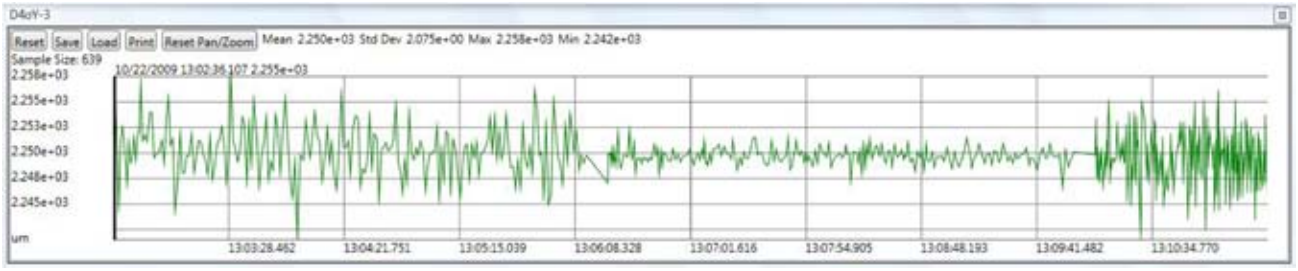
Small sample of possible measurements out of a list of 55



Sample of calculation results with statistics applied

Multiple Charting Options

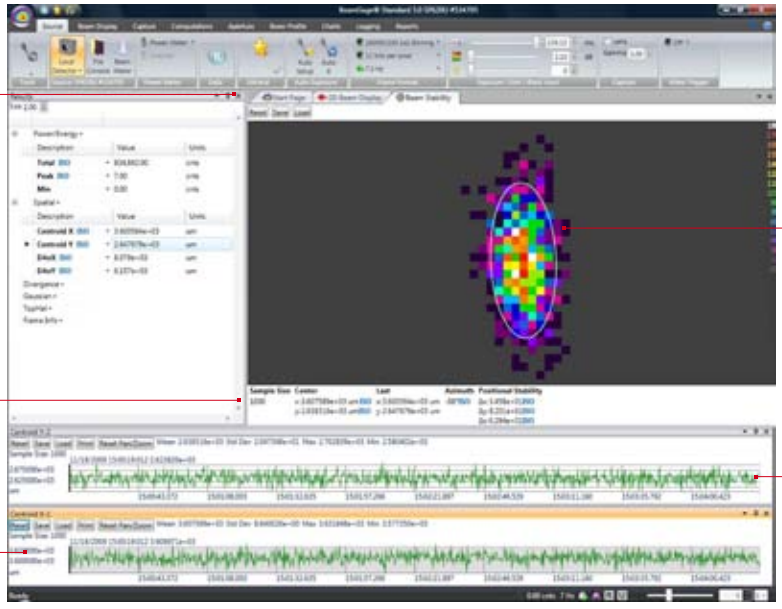
You can create strip charts for stability observations on practically any of the calculations options available. (See next page for sample listing). Charts enable tracking of short or long term stability of your laser.



Strip chart of beam D4sigma width. Note how changing conditions affects the width repeatability.
Beam intensity changed over 10db, making noise a significant factor in measurement stability.

Beam Pointing Stability

Open the Pointing Stability Window to collect centroid and peak data from the core system and display it graphically.
View a chart recorder and statistical functions in one interface:



Peak location scatter plot with histogram color-coding.

A centroid location scatter plot with histogram color-coding.

Set a sample limit, and specify the results items to graph on the strip chart.

A pointing stability strip chart presents data over time for the Centroid X and Y, Peak X and Y and centroid radius from an origin or from the mean centroid.

The radius is referenced from either an Origin established in BeamGage or from the continuously calculated Average Centroid position.

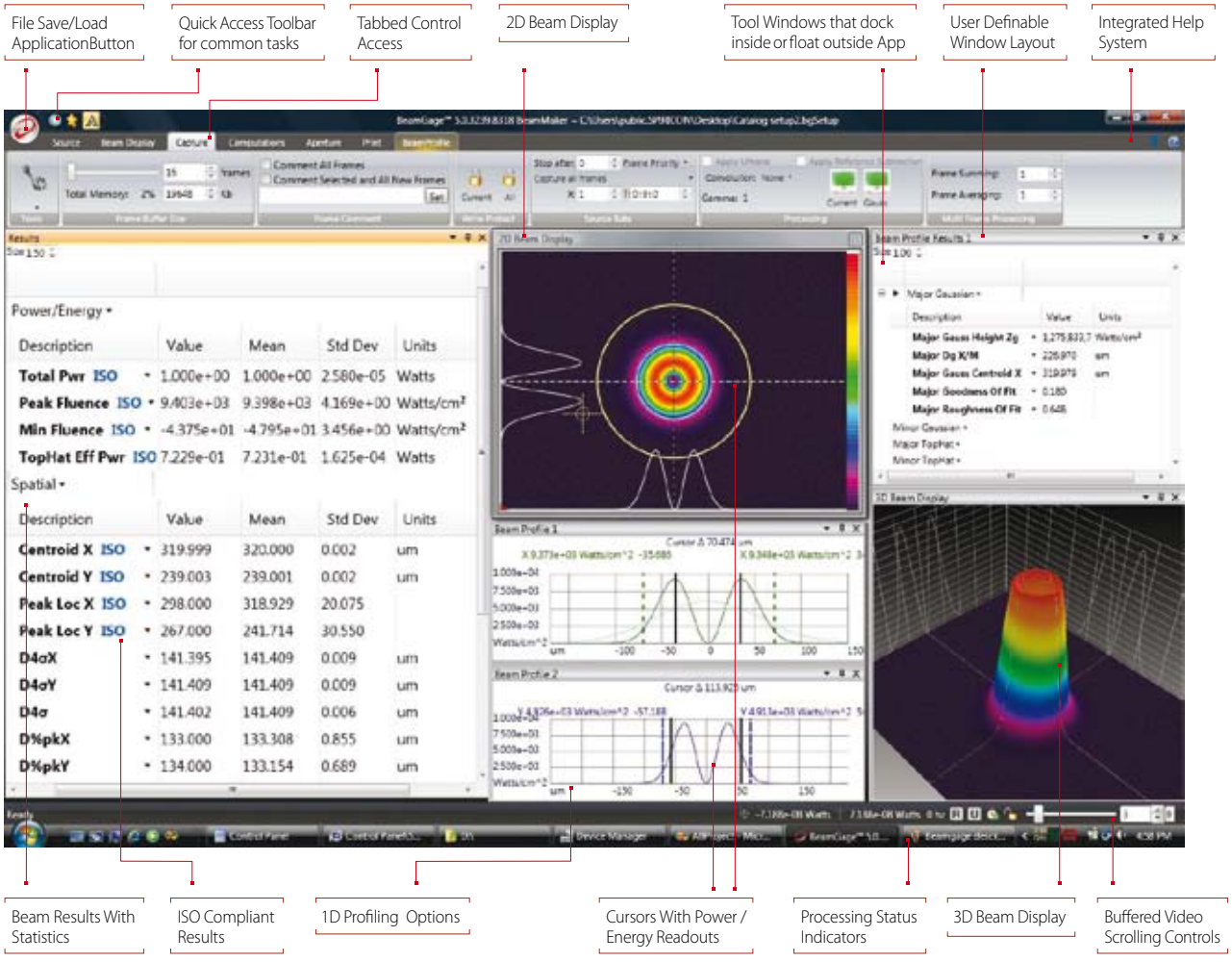
Easy to Use and Powerful

BeamGage is the only beam profiler on the market using modern Windows Vista and Windows 7 navigation tools. The menu system of BeamGage is easy to learn and easy to use with most controls only one mouse click away. Some ribbon toolbar examples:

Some of the Beam Display options (Display access options under the Tools tab on the left).

Some of the Beam Capture options.

BeamGage Main Display Screen


File Save/Load ApplicationButton
Quick Access Toolbar for common tasks
Tabbed Control Access
2D Beam Display
Tool Windows that dock inside or float outside App
User Definable Window Layout
Integrated Help System
Beam Results With Statistics
ISO Compliant Results
1D Profiling Options
Cursors With Power / Energy Readouts
Processing Status Indicators
3D Beam Display
Buffered Video Scrolling Controls

Pass / Fail with Password Protection for Production Testing

BeamGage allows the user to configure the displayed calculations; set-up the screen layout and password protect the configuration from any changes. This permits secure product testing as well as data collection for Statistical Process Control (SPC), all while assuring the validity of the data.

Spatial

Description	Value	Mean	Std Dev	Max	Min	Units
Centroid X ISO	3.603333e+03	3.611520e+03	8.863239e+00	3.629877e+03	3.588919e+03	um
Centroid Y ISO	2.618638e+03	2.637664e+03	2.209601e+01	2.690581e+03	2.596395e+03	um
Peak Loc X ISO	1.97560e+03	3.36032e+03	2.07685e+03	6.81120e+03	4.84000e+01	um
Peak Loc Y ISO	2.86440e+03	3.69962e+03	1.33801e+03	5.27560e+03	2.20000e+01	um
D4σX ISO	8.075e+03	8.058e+03	1.419e+01	8.085e+03	8.028e+03	um
D4σY ISO	6.112e+03	6.095e+03	3.920e+01	6.201e+03	5.998e+03	um
D4σ ISO	7.161e+03	7.144e+03	1.965e+01	7.201e+03	7.104e+03	um

Failures (or successes) can be the impetus for additional actions including a TTL output signal or PC beep and the termination of further data acquisition.

Camera Compatibility

For lasers between 190-1320nm wavelenghts, BeamGage interfaces to silicon CCD Firewire (1394) and USB cameras. For applications between 1440-1605nm, BeamGage supports cost effective phosphor coated CCD cameras. For demanding applications between 900-1700nm, BeamGage supports an InGaAs camera. And for applications in the ultraviolet, 13-355nm, or far infrared or Terahertz range, 1.06-3000nm, BeamGage supports Spiricon's Pyrocam III, pyroelectric array camera.

190-1100nm

Model	SP503U	SP620U	GRAS20	Gevicam	L11059
Spectral Response nm	190 - 1100nm*	190 - 1100nm*	190 - 1100nm*	190 - 1100nm*	190 - 1100nm*
Application	½" format, slim profile, wide dynamic range, CW & pulsed lasers, adjustable ROI	1/1.8" format, high resolution, wide dynamic range, pulsed lasers, CW YAG, adjustable ROI	1/1.8" format, high resolution, CW YAG, adjustable ROI	1/1.8" format, high resolution, networkable, long cable distances, adjustable ROI	36mm x 24mm, 35mm format for large beams, CW YAG, Adjustable ROI
Number of Elements	640 x 480	1600 x 1200	1600 x 1200	1600 x 1200	4008 x 2672
Interface Style	USB	USB	Firewire 1394b	Gigbit Ethernet	USB
Windows 05 support	Windows 7 (32/64), Vista (32/64) or XP (32) Pro			Windows 7 (32/64) or Vista (32/64)	Windows 7 (32/64), Vista (32/64) or XP (32) Pro

1440-1605nm

Model	SP503U-1550	SP620U-1550	GRAS20-1550
Spectral Response nm	1440 - 1605nm	1440 - 1605nm	1440 - 1605nm
Application	NIR wavelengths, ½" format, low resolution	NIR wavelengths, 1/1.8" format, low resolution, adjustable ROI and binning	NIR wavelengths, 1/1.8" format, adjustable ROI
Number of Elements	640 x 480	1600 x 1200	1600 x 1200
Interface Style	USB	USB	Firewire 1394b
Windows 05 support	Windows 7 (32/64), Vista (32/64) or XP (32) Pro		

900-1700nm

Model	XEVA 100Hz
Spectral Response	900 - 1700nm
Application	High resolution InGaAS performance, NIR wavelengths
Number of Elements	320 x 256
Interface Style	USB 2.0
Windows 05 support	Windows 7 (32), Vista (32) or XP (32) Pro

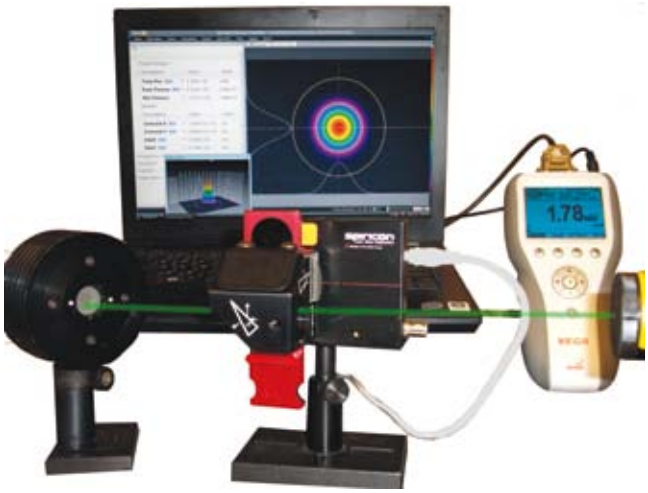
13-355nm & 1.06-3000µm

Model	Pyrocam III
Spectral Response nm	13-355nm & 1.06-3000µm
Application	UV & Far IR
Number of Elements	124 x 124
Interface Style	Firewire 1394a
Windows 05 support	Windows 7 (32/64), Vista (32/64) or XP (32) Pro

BeamGage-Standard Unique Features

Power/Energy Calibration

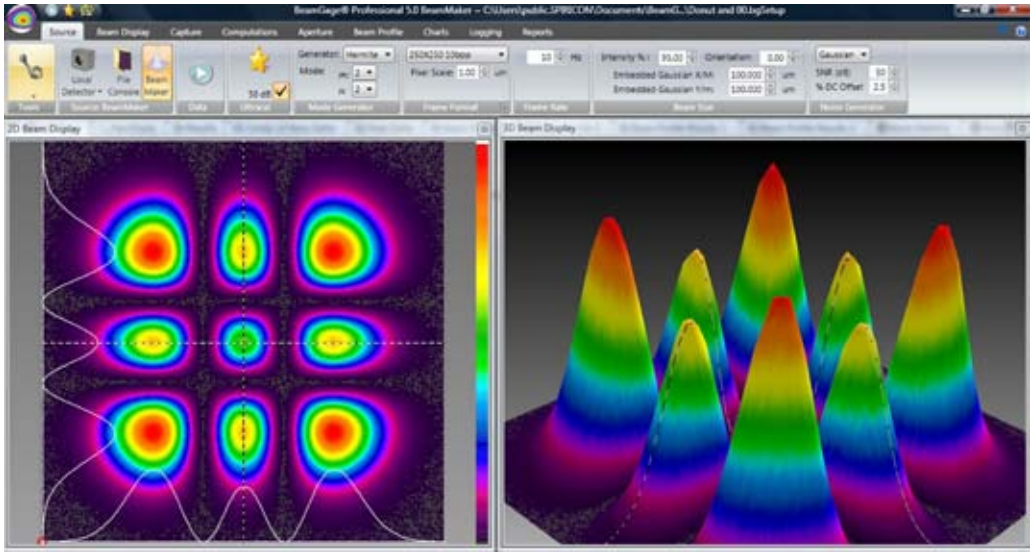
Using the USB output from select Ophir power/energy meters, the BeamGage application will display measured power/energy values from the full range of Ophir thermopile, photodiode and pyroelectric sensors. Pulsed lasers can be synced up to 100Hz, or the frame rate of the triggered camera, whichever is less. This is the first time in the industry a laser power meter has been married to a laser beam profile system.



BeamGage is the only product to integrate profiling and power meter measurements

BeamMaker®; Numerical Beam Profile Generator

BeamGage contains a utility, BeamMaker, that can synthetically generate beam profile data by modeling either Laguerre, Hermite or donut laser beams in various modal configurations. BeamMaker permits the user to model a beam profile by specifying the mode, size, width, height, intensity, angle, and noise content. Once generated the user can then compare the theoretically derived measurements to measurements including experimental inaccuracies produced by the various measurement instruments and environmental test conditions. Users can now analyze expected results and confirm if measurement algorithms will accurately measure the beam even before the experiment is constructed. BeamMaker can help laser engineers, technicians and researchers understand a beam's modal content by calculating results on modeled beams for a better understanding of real laser beam profiles. BeamMaker is to laser beam analysis as a function generator is to an oscilloscope.



BeamMaker producing a synthetically generated Hermite TEM_{22} beam and displayed in both 2D and 3D

Integrated automatic Help linked into the Users Guide

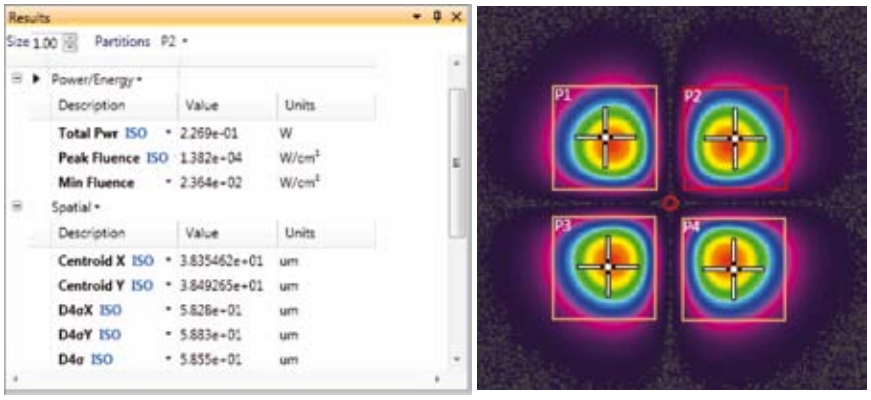
Touch sensitive Tool tips are available on most all controls, and "What's This" help can provide additional details. Confused about what something is or forgot how it works, just go to the top right corner and touch the "What's This" help icon, drag it and right click on the control or menu item that you want more info about and you are taken to the explanation within the BeamGage Users Guide.

3.2.1.2 BeamGage®-Professional

Professional is an upgrade version of BeamGage-Standard that has all of the BeamGage-Standard features plus additional functionality.

Image Partitioning

Partitioning allows the user to subdivide the camera image into separate regions, called partitions, and compute separate beam results within each partition. When using partitioning special results items can be displayed that relate to delta values between the computed centroids or peaks of each partition. Partitioning is useful to enable separate analysis of individual beams when multiple beams impinge on the camera simultaneously. This feature is particularly useful when analyzing multiple fibers in a single bundle.



Shown is an example of the results for partition P2 and its related display frame. Observe that the selected partition is highlighted in RED. The crosshair in each partition is user controlled. The crosshair can be moved to a new position with the mouse or can be numerically positioned using the expanded controls that appear when a partition is created.

Automation Interface

BeamGage Professional provides an automation interface via .Net components to allow customers the ability to build custom applications' that incorporate the laser beam analysis and processing power of BeamGage. The BeamGage automation interface allows developers to control BeamGage programmatically via a set of "puppet strings" known as the automation interface. The automation interface was developed to provide the ability to base control decisions for a second application on results and behaviors recognized by BeamGage. With this ability users can quickly and efficiently meet their manufacturing/analysis goals with minimum human interaction.

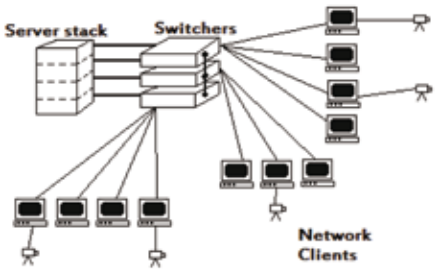
The automation interface was designed to achieve two main goals. First, to allow the BeamGage user to programmatically do what they could otherwise do via the graphical user interface (GUI). Second, to expose stable interfaces to the user that will not change, causing breaks to their dependant code. Interface examples for LabVIEW, Excel and .Net VB are included.

3.2.1.3 BeamGage®-Enterprise

Enterprise is an upgrade version of BeamGage-Professional that has all of the BeamGage-Standard and -Professional features plus additional functionality.

Networking

BeamGage Enterprise Edition (BGE) allows cameras to be accessed and shared over an Ethernet local area network (LAN) that shares a common domain.



3.2.1.4 Software Comparison Chart

Features	BeamGage® Standard	BeamGage® Professional (all features in Standard plus)	BeamGage® Enterprise (all features in Pro plus)
Features Overview	User selectable for either best "accuracy" or "ease of use"		
	Supports our patented Ultracal algorithm plus Auto-setup and Auto-exposure capabilities		
	Extensive set of ISO quantitative measurements		
	Support for USB, Firewire and Pyrocam III cameras. Firewire cameras limited to 32bit OS only.	Supports InGaAs cameras in 32bit OS only	Supports Gig-E camera in both 32 and 64 bit OS
	Support for USB, Firewire and Pyrocam III	InGaAs	GigE
	New Beam Maker® beam simulator for algorithm self validation. See below for more detailed description.		
	Simultaneous 2D and 3D displays		
	Multi-instance, multi-camera use		
			Supports networked USB Firewire and Pyrocam III cameras. Gig-E in a future release.
	Results synchronised to select models of Ophir power/energy meters. Supported products include: Vega, Nova II, Pulsar, USBI and Juno, in both 32 and 64bit OS. (Quasar is not supported)		
	Supports Satellite windows on multiple monitors		
	Continuous zoom scaling in both 2D and 3D		
		Window partitioning to allow analysis of multiple beams on a single camera	
	Camera ROI support on USB and Firewire cameras		
	Manual and Auto-aperturing to reduce background effects		
	Pass/Fail on all results items, w/multiple alarm options		
	Beam Pointing Stability scatter plot and stripchart results		
	Full featured logging capabilities in a reloadable		
	Industry standard data file format		
	Configurable Report Generator that allows cut and paste of results, images and settings.		
		NET Automation interface that. allows for remote control	
		Examples in LabView, Excel and .Net VB	
	Supports English, German, Japanese and Chinese Windows OS in both 32 and 64bit. Multilingual GUI in English, Japanes and Chinese.		
Quantitative Calculations; Basic Results	(per ISO 11145, 11146-1/-3, and 13694)		
Power/Energy Results	Total power or energy (Can be calibrated or sync'd to an external Ophir power/energy meter)		
	Peak power/energy density		
	Min. Fluence		
	Average pulse power		
	Peak pulse power		
	Device efficiency		
	% in Aperture		
Spatial Results	Peak and Centroid locations		
	Beam width		
	▪ Second Moment (D4s)		
	▪ Knife Edge 90/10		
	▪ Knife Edge (User selectable level)		
	▪ Percent of Peak (User selectable)		
	▪ Percent of Total Energy (User selectable)		
	▪ Encircled power smallest slit @ 95.4		
	▪ Moving slit (User selectable)		
	Beam diameter		
	▪ Average diameter (based on x/y widths)		
	▪ Second Moment (D4s)		
	▪ Encircled power smallest aperature 86.5		
	▪ Encircled power smallest aperature (User selectable level)		

Features	BeamGage® Standard	BeamGage® Professional (all features in Standard plus)	BeamGage® Enterprise (all features in Pro plus)
	Elliptical Results		
	▪ Elliptical orientation		
	▪ Ellipticity		
	▪ Eccentricity		
	Distance Measurement		
	▪ Cursor to Crosshair		
	▪ Centroid to Crosshair		
	Area Results		
	Beam cross-sectional area		
Divergence	Focal Length method		
	Far-field two-point method		
	Far-field Wide Angle method		
Gaussian Fit	2D whole beam fits		
	1D line fits		
	Height		
	Width X/Y		
	Centroid		
	Goodness of fit		
	Roughness of fit		
Tophat Results	2D and 1D		
	Flatness		
	Effective Area		
	Effective Power/Energy		
	Fractional Effective Power/Energy		
	Effective Average Fluence		
	Uniformity		
	Plateau Uniformity		
	Edge Steepness		
	1D or 2D surface inclination		
Other Quantitative Items	Frame Averaging		
	Frame Summing		
	Frame Reference Subtraction		
	Image Convolution		
	Camera signal/noise calculator		
	Row and Column summing with results loggable		
		Scalable Intensity Histogram, exportable	
		X or Y axial off axis image correction	
Beam Stability Displays and Results	(per ISO 11670)		
	Pointing Stabilty of Centroid		
	▪ Scatter Plot display w/histogram		
	▪ Mean Centroid		
	▪ Azimuth angle of the scatter		
	▪ Stability (M'/m'/S)		
	▪ Max Radius		
	▪ X/Y centroid/peak Strip chart plots		
	▪ Sample/Time controlled		
	▪ Pass/Fail limits		
	▪ Auto scaling		
	▪ Beam Width/Diameter Strip Charts with Results		
	▪ X/Y M/m beam widths plots		
	▪ Beam Diameter plot		
	▪ Mean/Std Dev/Min/Max results displayed		
	▪ Power/Energy Strip Charts		
	▪ Total Power/Energy plot		
	▪ Peak fluence plot		
	▪ Avg Power plot		
	▪ Elliptical Results Strip Chart		
	▪ Elliptical orientation plot		
	▪ Ellipticity plot		
	▪ Eccentricity plot		
	▪ Mean/Std Dev/Min/Max results displayed		
Beam Profile Display Options	Utilizes advanced hardware accelerated graphics engines. All display windows can be satellited to utilize multiple display monitors.		
	Can open one each simulaneous 2D and 3D beam display windows		
	Common color palette for 2D and 3D displays		
	Can open X and/or Y 1D beam slice profiles overlaid onto the 2D or 3D displays or in separate windows		

Features	BeamGage® Standard	BeamGage® Professional (all features in Standard plus)	BeamGage® Enterprise (all features in Pro plus)
	Continuous software zooming in both 1D, 2D and 3D displays		
	Pan to any detector location		
	Continuous Z axis display magnitude scaling		
	Multiple 128 color palettes user selectable		
	Results items can be pasted into 2D, 3D, 1D, Pointing stability or Chart display windows.		
		Able to partition the camera imager into multiple regions with separate results.	
1D Features	Available overlaid with 2D and 3D or in separate windows		
	X any Y plots on separate or combined displays		
	1D displays with basic results and column row summing option		
	Tophat 1D displays with Tophat results		
	Gaussian 1D displays with Gaussian fit results		
	1D Profile display of the Gauss fit results on 1D, 2D and 3D displays		
2D Features	Continuously zoomable and resizable displays in satellitable window		
	Continuous Z axis display magnitude scaling		
	Zoomable to subpixel resolution for origin and cursor placements		
	Pixel boundaries delinated at higher zoom magnifications		
	Adjustable Cursors that can track peak or centroid		
	Adjustable Crosshairs that can track peak or centroid		
	Adjustable manual apertures		
	Viewable Auto-aperture placement		
	Displayed beam width marker		
	Integrated Mouse actuated pan/zoom controls		
	Separate 2D pan/zoom window to show current view in 2D beam display		
	Manual or fixed origin placement		
		Ability to create partitions using the manual aperture controls	
3D Features	3D graphics utilize solid surface construction with lighting and shading effects		
	Integrated Mouse actuated pan/zoom/tilt/rotate controls		
	Selectable Mesh for drawing speed vs resolution control		
	Continuously zoomable and resizable displays in satellitable window		
	Continuous Z axis display magnitude scaling		
	User enabled backplanes with cursor projections		
Partitioning		Users can subdivide the imager into separate beam measurement regions. All enabled results are computed inside of each partition	
		The manual aperture is used to define and create rectangular partition	
		When partitioning is enabled some new results items will be enabled	
		Centroid measurements between beams in each partition can be performed	
		Partitioned imagers must have a single origin common to all partitions. All coordinate results are globally referenced to this single origin	
Statistical Analysis	Performed on all measurement functions with on-screen display		
	▪ Choices of intervals		
	▪ Manual start/stop		
	▪ Time from 1 second to 1000 hours		
	▪ Frames from 2 to 99,999 Measurements reported		
	▪ Current frame data, Mean, Standard Deviation, Minimum, Maximum of each calculation performed		
	Controls integrated with beam stability results, scatter and strip chart plots		

Features	BeamGage® Standard	BeamGage® Professional (all features in Standard plus)	BeamGage® Enterprise (all features in Pro plus)
File types	Industry Standard HDF5 data and setup file format which are compatable in third party applications such as MatLab and Mathmatica		
	Math program and Excel compatable ASCII-csv results files		
	Graphics in jpg file format		
	Legacy file compatability with LBA formats		
	A user defined single file output that can contain settings, beam displays, beam profiles, charts, results, etc. in either .pdf or .xps file formats		
Printing	Images, reports, results, graphs, charts, statistics and setup information		
	Option to print many frames in a single operation		
	WYSIWYG images		
Pass/Fail	Set Maximum/Minimum limits on all calculations and statistics		
	Red/Green font color indication on result items		
	Multiple choices for indication of failed parameters, including TTL pulse for external alarm		
	Master pass/fail which triggers alarm on any failure		
	USB signal, beep, stop, and log alarm options		
Logging	Video Data Logging Formats: HDF5, ASCII-csv		
	Results in ASCII-csv		
	Pictures 2D and 3D in jpg, gif, tiff, bmp, png file formats		
	Charts in ASCII-csv		
	Cursor Data in ASCII-csv		
	Row/Column summed in ASCII-csv		
	Continuous Logging		
	Time Interval Logging		
	Frame Count Logging		
	Periodic Sampling		
	Pass/Fail Sampling		
	Burst Sampling, after a user specified time interval, sample a user specified number of frames		
Exporting	Convert frame buffer data to third party format		
	Export a user specified number of frames from the buffer		
	Export Image Data: ASCII-cvs		
	Export Results: ASCII-csv		
	Export Picture: jpg, gif, tiff, bmp, png file formats supported		
	Export Cursor Data: ASCII-cvs		
	Export Row/Column summed: ASCII-cvs		
	Export Image Data in Aperture		
Automation Interface (.NET)		Automation Interface with examples in LabVIEW, Excel and .Net VB	
		Automate launch and termination of the application	
		Automate start, stop, Ultracal, Auto-X and Auto Setup	
		Automate the loading of application setups	
		Automate control of most camera settings	
		Automate a subset of the application features and controls	
		Automate the capture of Binary Video Data	
		Automate the acquisition of application results	
		Automate the acquisition of application Images	
Integrated Help	PDF Operators Manual		
	Context Sensitive (Whats this?) Help		
	Context Sensitive Hints		
Signal Conditioning for Enhanced Accuracy	Spiricon's patented Ultracal enables more accurate beam measurement and display. Ultracal takes a multi- frame average of the baseline offset of each individual pixel to obtain a baseline accurate to approximately 1/8 of a digital count. This baseline offset is subtracted from each frame, pixel by pixel, to obtain a baseline correction accurate to 1/8 digital count. Spiricon's Ultracal method retains numbers		

Features	BeamGage® Standard	BeamGage® Professional (all features in Standard plus)	BeamGage® Enterprise (all features in Pro plus)
	less than zero that result from noise when the baseline is subtracted. Retaining fractional and negative numbers in the processed signal can increase the beam width measurement accuracy by up to 10X over conventional baseline subtraction and clip level methods. Spiricon's Ultracal conforms to the best method described in ISO 11146-3:2004.		
Frame Averaging	Up to 256 frames can be averaged for a signal-to-noise ratio, S/N, improvement of up to 16X (Noise is averaged up to 1/256th [8 fractional bits]). Data is processed and stored in a 32bit format.		
Frame Summing	Up to 256 frames can be summed to pull very weak signals out of the noise.		
	Due to the precise nature of Ultracal baseline setting, (i.e., a retention of both positive and negative noise components) summing of frames can be performed without generating a large offset in the baseline.		
Convolution (Adjacent Pixel Averaging)	Choice of 5 convolution algorithms for spatial filtering for both display and calculations. Spatial filtering improves the visual S/N.		
Beam Maker®	Beam Maker is a new feature that allows the user to model both Laguerre-Gaussian and Hermite-Gaussian laser beams in various modal configurations. With these models you have verification and validation tools that allows not only OSI but also the end user to verify BeamGage's basic beam width measurement algorithms. It can also be used to model laser beams with special input conditions such as signal-to-noise, background offset, and bits per pixel resolution. This allows the user to better understand the accuracy of measurements made under both optimum and adverse conditions. This tool provides the user with a method to validate algorithms against current ISO standards and methods. It can also be used to validate third party algorithms by making the output data available for use in third party applications.		
Camera Features	Camera features are governed by the capabilities of the various cameras that will interface with these software products, and second by which of these camera features are implimented in the software. This section will describe typical camera features supported in the application.		
	Black Level Control (used by Ultracal and Auto-X and Auto-setup)		
	Gain Control (used by Auto-X and Auto-setup)		
	Exposure Control (used by Auto-X and Auto-setup)		
	User Programmable ROI		
	Pixel Binning		
	Pixel Sampling		
	Bits per pixel setting		
	External Trigger Input		
	Trigger Delay		
	Strobe Output		
	Strobe Delay		
	External Trigger Probe		
	Internal Trigger Probe		
Camera related features in the applications	These are features related to but not generally dependent upon the camera design.		
	Gamma Correction		
	Gain Correction		
	Bad Pixel Correction		
	Lens Applied Option		
	Pixel scale settings		
	Magnification settings		
	Frame buffer settings		
	Ultracal		
	Enable Auto-X (auto exposure control)		
	Perform an Auto-Setup		
	8/10/12/14/16 bits per pixel		
	Select Format or ROI		
	Measure S/N ratio		
Trigger, Capture and Synchronization Methods	Capture methods are features related to the application while Synchronization methods relate more to the abilities of the specific camera. NOTE: Frame capture rates are determined by many factors and are not guaranteed for any specific operating configuration.		

Features	BeamGage® Standard	BeamGage® Professional (all features in Standard plus)	BeamGage® Enterprise (all features in Pro plus)
	Trigger modes		
	▪ CW - captures continuously, see Capture Options below		
	▪ Trigger-In from laser: Trigger pulses supplied to the camera		
	▪ Strobe-Out to laser: Strobe pulses output from the camera		
	▪ Video Trigger: Frame captured and displayed only when the camera sees a signal greater than a user set level		
	Capture options		
	▪ Capture options are redefined and are approached in a different manner than older products. The items listed below will allow for all of the previous methods but with more flexability than ever before		
	▪ Results Priority: Results priority will slow the capture rate to be in sync with the computational results and display updates		
	▪ Frame Priority: Frame priority will slow results and display updating to insure that frames are collected and stored in the frame buffer as fast as possible (replaces block mode)		
	▪ Stop After: Will collect a set number of frames and then stop (replaces Single-Shot mode)		
	▪ Periodic: Will collect frame at a programmed periodic rate		
	▪ Periodic Burst: Will collect frames in a Burst at programmed periodic rates		
	Post processing is still available but is done via a different mechanism and is limited to only data file sources		
Video Playback	Video playback, post processing and post analysis		
	User customizable playback rates		
	Video file quick pan/search controls		
	Whole video file playback looping with sub-selection looping		
	Playback Video produced by logging		
	Almost all measurements can be performed on video files		
System Requirements	PC computer running Windows7 (32/64) or XP (32) Pro Laptop or Desktop Note that some cameras require a 32bit OS. Consult factory for latest 64bit camera availability. 64bit OS required for Lw11058 camera.		
	Not all cameras run in all Microsoft 05 versions, see camera section for specifics		
	GHz Pentium style processor, dual core recommended		
	Minimum 2GB RAM (4GB required for Lw11058 camera)	Minimum 3-4GB RAM	
	Accelerated Graphics Processor		
	Hard drive space suitable to hold the amount of video data you expect to store (50-100 GB recommended)		
	Provision for PCI-Express, FireWire, USB2 or Gigabit Ethernet input depending on camera. Interface hardware provided with a cameras except USB2.		

Ordering Information

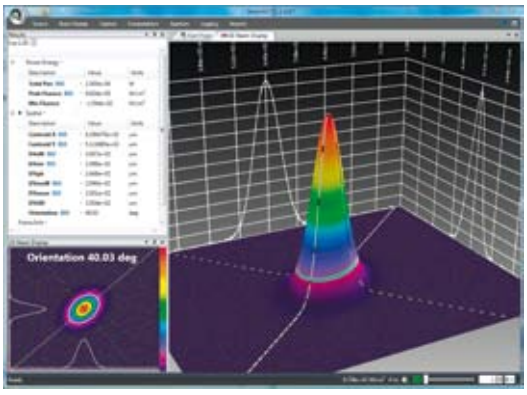
Item	Description	P/N
BeamGage Standard USB2 Beam Profiler Systems (camera and software)		
BGS-USB-SP503	BeamGage Standard software, software license, ½" format 640x480 pixel camera with 4.5mm CCD recess. Comes with USB cable and 3 ND filters.	SP90197
BGS-USB-SP503-1550	BeamGage Standard software, software license, ½" format 640x480 pixel camera with 4.5mm CCD recess. Phosphor coated to 1550 nm. Comes with USB cable and 3 ND filters.	SP90198
BGS-USB-SP620	BeamGage Standard software, software license, 1/1.8" format 1600x1200 pixel camera with 4.5mm CCD recess. Comes with USB and cable and 3 ND filters.	SP90199
BGS-USB-SP620-1550	BeamGage Standard software, software license, 1/1.8" format 1600x1200 pixel camera with 4.5mm CCD recess. Phosphor coated to 1550 nm. Comes with USB and cable, 3 ND filters.	SP90200
BeamGage Standard FireWire Beam Profiler Systems (camera and software)		
BGS-FWB-GRAS20,DESKTOP	BeamGage Standard software, software license, 1/1.8" format 1600x1200 1394b camera with 17.5mm C-mount recess. Comes with 1394b and trigger cable, PCI-Express interface card and 3 ND filters. Desktop model.	SP90202D
BGS-FWB-GRAS20,LAPTOP	BeamGage Standard software, software license, 1/1.8" format 1600x1200 1394b camera with 17.5mm C-mount recess. Comes with 1394b and trigger cable, Laptop PCI-Express interface, power supply and 3 ND filters. Laptop Model.	SP90202L
BGS-FWB-GRAS20-1550,DESKTOP	BeamGage Standard software, software license, 1/1.8" format 1600x1200 Phosphor coated 1550nm sensor, 1394b camera with 17.5mm C-mount recess. Comes with 1394b and trigger cable, PCI-Express interface card and 3 ND filters. Desktop model.	SP90203D
BGS-FWB-GRAS20-1550,LAPTOP	BeamGage Standard software, software license, 1/1.8" format 1600x1200 Phosphor coated 1550nm sensor 1394b camera with 17.5mm C-mount recess. Comes with 1394b and trigger cable, PCI-Express interface card and 3 ND filters. Laptop Model.	SP90203L
BeamGage Professional USB2 Beam Profiler Systems (camera and software)		
BGP-USB-SP503	BeamGage Professional Edition software, software license, 1/2" format 640x480 pixel camera with 4.5mm CCD recess. Comes with USB cable and 3 ND filters.	SP90236
BGP-USB-SP503-1550	BeamGage Professional Edition software, software license, 1/2" format 640x480 pixel camera with 4.5mm CCD recess. Phosphor coated 1550nm sensor. Comes with USB cable and 3 ND filters.	SP90237
BGP-USB-SP620	BeamGage Professional Edition software, software license, 1/1.8" format 1600x1200 pixel camera with 4.5mm CCD recess. Comes with USB cable and 3 ND filters.	SP90238
BGP-USB-SP620-1550	BeamGage Professional Edition software, software license, 1/1.8" format 1600x1200 pixel camera with 4.5mm CCD recess. Phosphor coated 1550nm sensor. Comes with USB cable and 3 ND filters.	SP90239
BGP-USB-L11059	BeamGage Professional Edition software, software license, 35mm format 4008x2672 pixel camera. Comes with universal power supply, USB cable and 3 ND filters.	SP90320
BGP-USB-XC130	BeamGage Professional Edition software, software license, 320x256 pixel InGaAs camera with C-mount recess. .9 to 1.7um spectral band. Comes with universal power supply, USB cable, external trigger cable and 3 ND filters (consult factory for other camera options).	SP90241
BeamGage Professional FireWire Beam Profiler Systems (camera and software)		
BGP-FWB-GRAS20-DESKTOP	BeamGage Professional Edition software, software license, 1/1.8" format 1600x1200 pixel camera with 12.5mm C-mount CCD recess. Comes with 1394b and trigger cables, PCI-Express interface card and 3 ND filters. Desktop model.	SP90242D
BGP-FWB-GRAS20-LAPTOP	BeamGage Professional Edition software, software license, 1/1.8" format 1600x1200 pixel camera with 12.5mm C-mount CCD recess. Comes with 1394b and trigger cables, PCI-Express interface card, camera power supply, and 3 ND filters. Laptop model.	SP90242L
BGP-FWB-GRAS20-1550-DESK	BeamGage Professional Edition software, software license, 1/1.8" format 1600x1200 pixel camera with 12.5mm C-mount CCD recess. Phosphor coated 1550nm sensor. Comes with 1394b and trigger cables, PCI-Express interface card and 3 ND filters. Desktop model.	SP90243D
BGP-FWB-GRAS20-1550-LAPTP	BeamGage Professional Edition software, software license, 1/1.8" format 1600x1200 pixel camera with 12.5mm C-mount CCD recess. Phosphor coated 1550nm sensor. Comes with 1394b and trigger cable, PCI-Express interface card, camera power supply, and 3 ND filters. Laptop model.	SP90243L
BeamGage Enterprise USB2 Beam Profiler Systems (camera and software)		
BGE-USB-SP503	BeamGage Enterprise Edition software, software license, 1/2" format 640x480 pixel camera with 4.5mm CCD recess. Comes with USB cable and 3 ND filters.	SP90246
BGE-USB-SP503-1550	BeamGage Enterprise Edition software, software license, 1/2" format 640x480 pixel camera with 4.5mm CCD recess. Phosphor coated 1550nm sensor. Comes with USB cable and 3 ND filters.	SP90247
BGE-USB-SP620	BeamGage Enterprise Edition software, software license, 1/1.8" format 1600x1200 pixel camera with 4.5mm CCD recess. Comes with USB cable and 3 ND filters.	SP90248
BGE-USB-SP620-1550	BeamGage Enterprise Edition software, software license, 1/1.8" format 1600x1200 pixel camera with 4.5mm CCD recess. Phosphor coated 1550nm sensor. Comes with USB cable and 3 ND filters.	SP90249
BGE-USB-L11059	BeamGage Enterprise Edition software, software license, 35mm format 4008x2672 pixel camera. Comes with universal power supply, USB cable and 3 ND filters.	SP90321
BGE-USB-XC130	BeamGage Enterprise Edition software, software license, 320x256 pixel InGaAs camera with C-mount recess. .9 to 1.7um spectral band. Comes with universal power supply, USB cable, external trigger cable and 3 ND filters (consult factory for other camera options).	SP90251
BeamGage Enterprise Gig-E Beam Profiler Systems (camera and software)		
BGE-GigE-OSI182000	BeamGage Enterprise Edition software, software license, 1/1.8" format 1600x1200 pixel Gig-E camera with 17.5mm C-mount CCD recess. Comes with Cat5e cable, power supply with ext trigger adapter, Ethernet destop and laptop PCI-Express cards and 3 ND filters.	SP90269
BGE-GigE-OSI182000-1550	BeamGage Enterprise Edition software, software license, 1/1.8" format 1600x1200 pixel Gig-E camera with 17.5mm C-mount CCD recess. Phosphor coated 1550nm sensor. Comes with Cat5e cable, power supply with ext trigger adapter, Ethernet destop and laptop PCI-Express cards and 3 ND filters.	SP90272

Ordering Information

Item	Description	P/N
BeamGage Enterprise FireWire Beam Profiler Systems (camera and software)		
BGE-FWB-GRAS20-DESKTOP	BeamGage Enterprise Edition software, software license, 1/1.8" format 1600x1200 pixel camera with 17.5mm C-mount CCD recess. Comes with 1394b and trigger cable, PCI-Express interface card and 3 ND filters. Desktop model.	SP90252D
BGE-FWB-GRAS20-LAPTOP	BeamGage Enterprise Edition software, software license, 1/1.8" format 1600x1200 pixel camera with 17.5mm C-mount CCD recess. Comes with 1394b and trigger cable, PCI-Express interface card, camera power supply, and 3 ND filters. Laptop model.	SP90252L
BGE-FWB-GRAS20-1550-DESK	BeamGage Enterprise Edition software, software license, 1/1.8" format 1600x1200 pixel camera with 17.5mm C-mount CCD recess. Phosphor coated 1550nm sensor. Comes with 1394b and trigger cable, PCI-Express interface card and 3 ND filters. Desktop model.	SP90253D
BGE-FWB-GRAS20-1550-LAPTP	BeamGage Enterprise Edition software, software license, 1/1.8" format 1600x1200 pixel camera with 17.5mm C-mount CCD recess. Phosphor coated 1550nm sensor. Comes with 1394b and trigger cable, PCI-Express interface card, camera power supply, and 3 ND filters. Laptop model.	SP90253L
Software Upgrades		
BEAMSTAR TO BGS UPGRADE	Upgrade any BeamStar FX or SP based product to BeamGage Standard Edition. Requires a camera key to activate. (SP cameras may require a firmware upgrade to enable ROI features).	SP90219
BEAMSTAR TO BGP UPGRADE	Upgrade any BeamStar FX or SP based product to BeamGage Professional Edition. Requires a camera key to activate (SP cameras may require a firmware upgrade to enable ROI features).	SP90229
BEAMSTAR TO BGE UPGRADE	Upgrade any BeamStar FX or SP based product to BeamGage Enterprise Edition. Requires a camera key to activate (SP cameras may require a firmware upgrade to enable ROI features).	SP90230
LBA TO BGS UPGRADE	Upgrade any LBA-FW/USB/USB-SP based product to BeamGage Standard Edition. Requires a camera key to activate (Older Pyrocam III's require a Firmware Upgrade).	SP90210
LBA TO BGP UPGRADE	Upgrade any LBA-FW/USB/USB-SP based product to BeamGage Professional Edition. Requires a camera key to activate (Older Pyrocam III's require a Firmware Upgrade).	SP90231
LBA TO BGE UPGRADE	Upgrade any LBA-FW/USB/USB-SP based product to BeamGage Enterprise Edition. Requires a camera key to activate (Older Pyrocam III's require a Firmware Upgrade).	SP90232
BGS TO BGP UPGRADE	Upgrade BeamGage Standard Edition to Professional Edition. Requires a new camera key to activate.	SP90233
BGS TO BGE UPGRADE	Upgrade BeamGage Standard Edition to Enterprise Edition. Requires a new camera key to activate.	SP90234
BGP TO BGE UPGRADE	Upgrade BeamGage Professional Edition to Enterprise Edition. Requires a new camera key to activate.	SP90235
PC Accessories for Cameras		
PCI-Express FireWire 1394a/b Desktop Card	PCI-Express, IEEE 1394a/b FireWire card for installation to desktop PC's. Card has both 1394a and 1394b compatible ports. Compatible with all LBA and BeamGage FireWire systems.	SP90164
1394b FireWire Cable	1394b FireWire cable, 4.5 meter length.	SP90166
1394a/b Adapter Cable	1394a-6 to 1394b-9 adaptor cable, 4.5 meter length.	SP90207
1394b FireWire Power Supply	External Wall cube power supply for 1394b CardBus and PCI-Express/34 Laptop Adapters.	SP90167
USB A-B Cable	USB Cable with A to B connectors, 5 meter length.	SP90204
USB A-mini B Cable	USB Cable with A to mini-B connectors, 5 meter length.	SP90205
USB-Pass/Fail Cable	Output Pass/Fail signals when BeamGage is in out mode	SP90060
Optical Synch for Pulsed Lasers		
Optical Trigger for FX and SP Cameras	Optical trigger assembly which can be mounted on camera or separately to sense laser pulses and synchronize FX and SP cameras with pulses. Comes with a BNC cable. Stand for mounting sold separately.	SPZ17005

3.2.2 BeamMic™

BeamMic™ – Basic Laser Beam Analyzer System

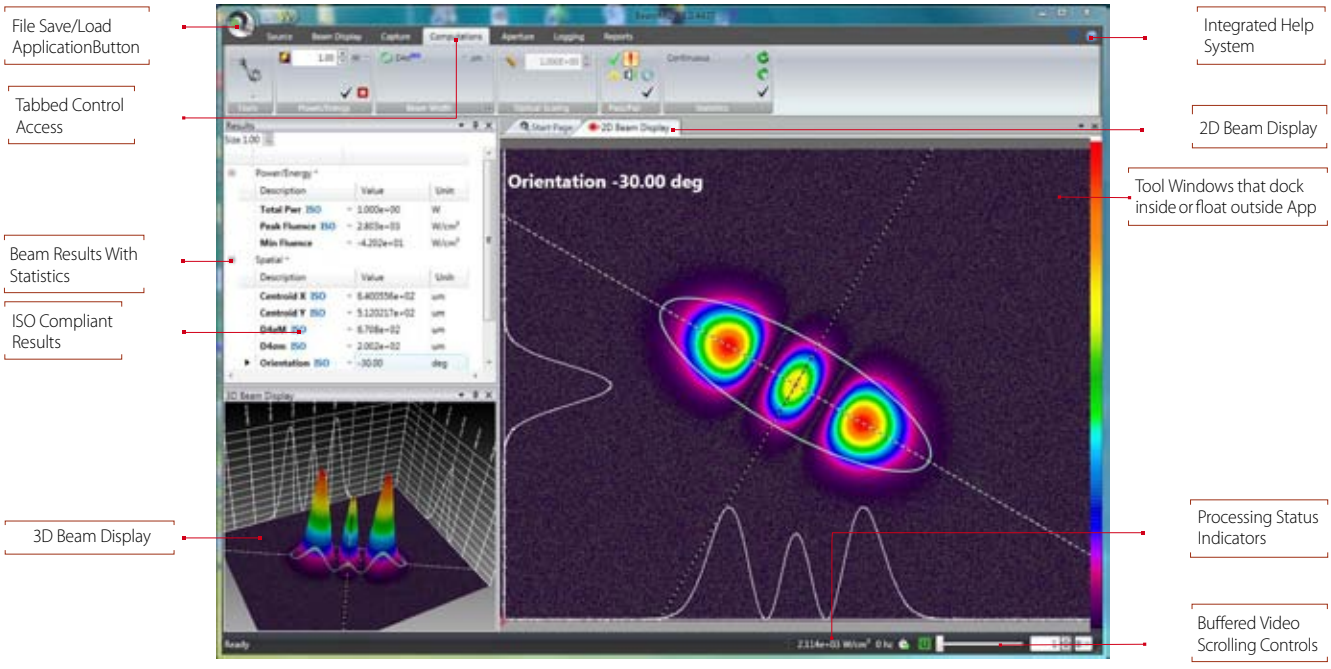


- High-speed false color beam intensity profile displays in both 2D and 3D
- Operates in Windows 7 (32/64) VISTA (32/64) and XP (32) Professional
- Numerical beam profile analysis employs patented advanced calibration algorithms.
- Extensive set of ISO quantitative measurements
- ISO beam width and diameter methods
- Enhanced window layout tools to get the most out of the desktop display area
- Pass/fail testing available on most all measured parameters
- Support for USB SPxxx series cameras
- Supports satellite windows on multiple monitors
- Continuous zoom scaling in both 2D and 3D
- Results logging capabilities exportable to Excel
- Industry std data file formats, HDF5 and CSV
- Configurable Report Generator that allows cut and paste of results, images and settings from .PDF and .XPS file types
- Statistical Analysis of all measured parameters
- Both Drawn and Auto Aperture for isolating beam data
- Integrated automatic Help linked into this .pdf Users Guide

The BeamMic series of laser beam analyzer systems are designed for entry level or basic profiling needs.

The beam's size, shape, uniformity or approximation to the expected power distribution, can make or break an application. Accurate knowledge of these parameters is essential to the accuracy of any laser-based application. As laser applications push the boundaries of laser performance it is becoming more critical to understand the operating criteria.

BeamMic Main Display Screen



Camera Compatibility

For lasers between 190-1100nm wavelenghts, BeamMic interfaces to silicon CCD USB cameras. For applications between 1440-1605nm, BeamMic supports cost effective phosphor coated CCD cameras.

190-1100nm

Model	SP503U	SP620U
Spectral Response nm	190 - 1100nm*	190 - 1100nm*
Application	½" format, slim profile, wide dynamic range, CW & pulsed lasers, adjustable ROI	1/1.8" format, high resolution, wide dynamic range, pulsed lasers, CW YAG, adjustable ROI
Pixel spacing	9.9µm X 9.9µm	4.40µm X 4.40µm
Number of Elements	640 x 480	1600 x 1200
Interface Style	USB	USB
Windows 05 support	Windows 7 (32/64), Vista (32/64) or XP (32) Pro	

* May be useable for wavelengths below 350nm but sensitivity is low and detector deterioration may occur. Therefore UV image converter is recommended. Although our silicon cameras have shown response out to 1320nm it can cause significant blooming which could lead to errors of beam width measurement. We would suggest our XC130 InGaAs camera and BeamGage for these wavelengths to give you the best measurements.

1440-1605nm

Model	SP503U-1550	SP620U-1550
Spectral Response nm	1440 - 1605nm	1440 - 1605nm
Application	NIR wavelengths, ½" format, low resolution	NIR wavelengths, 1/1.8" format, low resolution, adjustable ROI and binning
Pixel spacing**	9.9µm X 9.9µm	4.40µm X 4.40µm
Number of Elements	640 x 480	1600 x 1200
Interface Style	USB	USB
Windows 05 support	Windows 7 (32/64), Vista (32/64) or XP (32) Pro	

** Despite the small pixel size, the spatial resolution will not exceed 50µm due to diffusion of the light by the phosphor coating

Software Specifications

Features	BeamMIc - Laser Beam Analyzer Software
Features Overview	Designed for entry level or basic profiling needs
	Supports our patented Ultracal algorithm plus Auto-setup and Auto-exposure capabilities
	Extensive set of ISO quantitative measurements
	Support for high and low resolution USB cameras
	Simultaneous 2D and 3D displays
	Multi-instance, multi-camera use
	Supports Satellite windows on multiple monitors
	Continuous zoom scaling in both 2D and 3D
	Camera ROI support
	Manual and Auto-aperturing to reduce background effects
	Pass/Fail on all results items, w/multiple alarm options
	Results logging capabilities in a reloadable
	Industry standard data file format
	Configurable Report Generator that allows cut and paste of results, images and settings.
	Supports English, German, Japanese and Chinese Windows OS in both 32 and 64bit . Multilingual GUI in English, Japanese and Chinese.
Quantitative Calculations; Basic Results	(per ISO 11145, 11146-1/-3, and 13694)
Power/Energy Results	Total power or energy
	Peak power/energy density
	Min. Fluence
Spatial Results	Peak and Centroid locations
	Beam width
	▪ Second Moment (D4s)
	▪ Knife Edge 90/10
	▪ Knife Edge (User selectable level)
	▪ Percent of Peak (User selectable)
	▪ Percent of Total Energy (User selectable)
	▪ Encircled power smallest slit @ 95.4
	▪ Moving Slit (User Selectable)
	Beam diameter
	▪ Average diameter (based on x/y widths)
	▪ Second Moment (D4s)
	Elliptical Results
	▪ Elliptical orientation
	▪ Ellipticity
	▪ Eccentricity
2D Features	Continuously zoomable and resizable displays in satellitable window
	Continuous Z axis display magnitude scaling
	Zoomable to subpixel resolution for origin and cursor placements
	Pixel boundaries delinated at higher zoom magnifications
	Adjustable Cursors that can track peak or centroid
	Adjustable manual apertures
	Viewable Auto-aperture placement
	Displayed beam width marker
	Integrated Mouse actuated pan/zoom controls
	Manual or fixed origin placement
3D Features	3D graphics utilize solid surface construction with lighting and shading effects
	Integrated Mouse actuated pan/zoom/tilt/rotate controls
	Selectable Mesh for drawing speed vs resolution control
	Continuously zoomable and resizable displays in satellitable window
	Continuous Z axis display magnitude scaling
	User enabled backplanes with cursor projections
Statistical Analysis	Performed on all measurement functions with on-screen display
	▪ Choices of intervals
	▪ Manual start/stop
	▪ Time from 1 second to 1000 hours
	▪ Frames from 2 to 99,999 Measurements reported
	▪ Current frame data, Mean, Standard Deviation, Minimum, Maximum of each calculation performed

Features	BeamMIc - Laser Beam Analyzer Software

File types	Industry Standard HDF5 data and setup file format which are compatable in third party applications such as MatLab and Mathmatica
	Math program and Excel compatable ASCII-csv results files
	Graphics in jpg file format
	A user defined single file output that can contain settings, beam displays, beam profiles, results in either .pdf or .xps file formats
Printing	Images, reports, results, statistics and setup information
	Option to print many frames in a single operation
	WYSIWYG images
Pass/Fail	Set Maximum/Minimum limits on all calculations and statistics
	Red/Green font color indication on result items
	Multiple choices for indication of failed parameters, including TTL pulse for external alarm
	Master pass/fail which triggers alarm on any failure
	USB signal, beep, stop, and log alarm options
Logging	
	Results in ASCII-csv
	Continuous Logging
	Time Interval Logging
	Frame Count Logging
	Pass/Fail Sampling
Exporting	Convert frame buffer data to third party format
	Export a user specified number of frames from the buffer
	Export Image Data: ASCII-cvs
	Export Results: ASCII-csv
	Export Picture: jpg, gif, tiff, bmp, png file formats supported
	Export Image Data in Aperture
Integrated Help	PDF Operators Manual
	Context Sensitive (Whats this?) Help
	Context Sensitive Hints
Signal Conditioning for Enhanced Accuracy	Spiricon's patented Ultracal enables more accurate beam measurement and display. Ultracal takes a multi- frame average of the baseline offset of each individual pixel to obtain a baseline accurate to approximately 1/8 of a digital count. This baseline offset is subtracted from each frame, pixel by pixel, to obtain a baseline correction accurate to 1/8 digital count. Spiricon's Ultracal method retains numbers less than zero that result from noise when the baseline is subtracted. Retaining fractional and negative numbers in the processed signal can increase the beam width measurement accuracy by up to 10X over conventional baseline subtraction and clip level methods. Spiricon's Ultracal conforms to the best method described in ISO 11146-3:2004
Frame Averaging	Up to 256 frames can be averaged for a signal-to-noise ratio, S/N, improvement of up to 16X (Noise is averaged up to 1/256th [8 fractional bits]). Data is processed and stored in a 32bit format.
Frame Summing	Up to 256 frames can be summed to pull very weak signals out of the noise. Due to the precise nature of Ultracal baseline setting, (i.e., a retention of both positive and negative noise components) summing of frames can be performed without generating a large offset in the baseline.
Convolution (Adjacent Pixel Averaging)	Choice of 5 convolution algorithms for spatial filtering for both display and calculations. Spatial filtering improves the visual S/N.
Camera Features	Camera features are governed by the capabilities of the various cameras that will interface with these software products, and second by which of these camera features are implimented in the software. This section will describe typical camera features supported in the application.
	Black Level Control (used by Ultracal and Auto-X and Auto-setup)
	Gain Control (used by Auto-X and Auto-setup)
	Exposure Control (used by Auto-X and Auto-setup)
	Pixel Sampling
	Bits per pixel setting
	External Trigger Input
	Trigger Delay
	Strobe Output
	Strobe Delay
	External Trigger Probe
	Internal Trigger Probe
Camera related features in the applications	These are features related to but not generally dependent upon the camera design.
	Gamma Correction
	Gain Correction
	Bad Pixel Correction
	Lens Applied Option
	Pixel scale settings
	Magnification settings
	Frame buffer settings
	Ultracal
	Enable Auto-X (auto exposure control)
	Perform an Auto-Setup
	8 & 12 bits per pixel
	Select Format
	Measure S/N ratio
Features	**BeamMIc - Laser Beam Analyzer Software**

Trigger, Capture and Synchronization Methods	Capture methods are features related to the application while Synchronization methods relate more to the abilities of the specific camera. NOTE: Frame capture rates are determined by many factors and are not guaranteed for any specific operating configuration.
	Trigger modes
	▪ CW - captures continuously, see Capture Options below
	▪ Trigger-In from laser: Trigger pulses supplied to the camera
	▪ Strobe-Out to laser: Strobe pulses output from the camera
	▪ Video Trigger: Frame captured and displayed only when the camera sees a signal greater than a user set level
	Capture options
	▪ Capture options are redefined and are approached in a different manner than older products. The items listed below will allow for all of the previous methods but with more flexability than ever before
	▪ Results Priority: Results priority will slow the capture rate to be in sync with the computational results and display updates
	▪ Frame Priority: Frame priority will slow results and display updating to insure that frames are collected and stored in the frame buffer as fast as possible (replaces block mode)
	▪ Stop After: Will collect a set number of frames and then stop (replaces Single-Shot mode)
	▪ Periodic: Will collect frame at a programmed periodic rate
	▪ Periodic Burst: Will collect frames in a Burst at programmed periodic rates
	Post processing is still available but is done via a different mechanism and is limited to only data file sources
System Requirements	PC computer running Windows7 (32/64) or XP (32) Pro Laptop or Desktop
	GHz Pentium style processor, dual core recommended
	Minimum 2GB RAM (4GB required for Lw11058 camera)
	Accelerated Graphics Processor Hard drive space suitable to hold the amount of video data you expect to store (50-100 GB recommended)

Ordering Information

Item	Description	P/N
BeamMic USB2 Beam Analyzer Systems (camera and software)		
BM-USB-SP503	BeamMic software, software license, ½" format 640x480 pixel camera with 4.5mm CCD recess. Comes with USB cable and 3 ND filters.	SP90279
BM-USB-SP503-1550	BeamMic software, software license, ½" format 640x480 pixel camera with 4.5mm CCD recess. Phosphor coated to 1550 nm. Comes with USB cable and 3 ND filters.	SP90280
BM-USB-SP620	BeamMic software, software license, 1/1.8" format 1600x1200 pixel camera with 4.5mm CCD recess. Comes with USB and cable and 3 ND filters.	SP90281
BM-USB-SP620-1550	BeamMic software, software license, 1/1.8" format 1600x1200 pixel camera with 4.5mm CCD recess. Phosphor coated to 1550 nm. Comes with USB and cable, 3 ND filters.	SP90282
Software Upgrades		
BeamMic to BGS Upgrade	Upgrade BeamMic to BeamGage Standard Edition. Requires a camera key to activate. (SP cameras may require a firmware upgrade to enable ROI features).	SP90219
BeamMic to BGP Upgrade	Upgrade BeamMic to BeamGage Professional Edition. Requires a camera key to activate (SP cameras may require a firmware upgrade to enable ROI features).	SP90229
BeamMic to BGE Upgrade	Upgrade BeamMic to BeamGage Enterprise Edition. Requires a camera key to activate (SP cameras may require a firmware upgrade to enable ROI features).	SP90230
Optical Synch for Pulsed Lasers		
Optical Trigger for SP Cameras	Optical trigger assembly which can be mounted on camera or separately to sense laser pulses and synchronize SP cameras with pulses. Comes with a BNC cable. Stand for mounting sold separately.	SPZ17005
Recommended Optional		
LBS-300-BB	Dual beam splitters and configurable 9 ND filters for 190-1550nm; screws onto front of camera	SP90186

3.2.3 Cameras

3.2.3.1 190-1100nm USB Silicon CCD Cameras

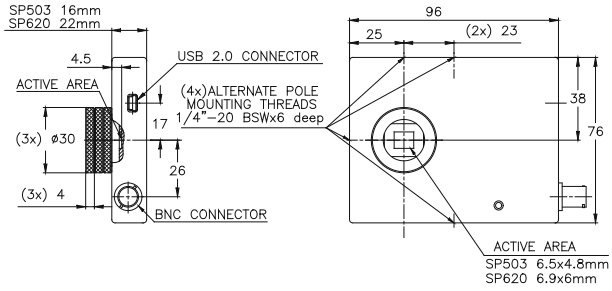
SP Series

Features

- USB 2.0 compatible
- 64dB true system dynamic range - highest in the industry
- Programmable high speed electronic shutter
- Spectral range: 190 - 1100nm
- Gain adjustable to accommodate a wide range of input levels
- Built in optical trigger synchronizes with even the shortest laser pulses.
- Slim profile and multiple mounting options

Built-in photodiode trigger

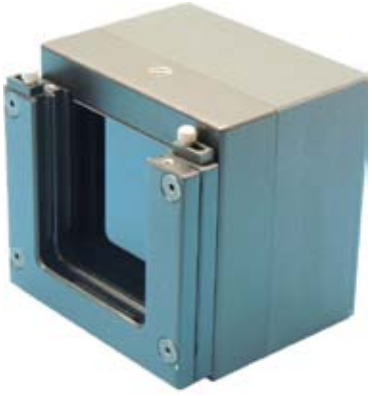
SP503U/SP620U



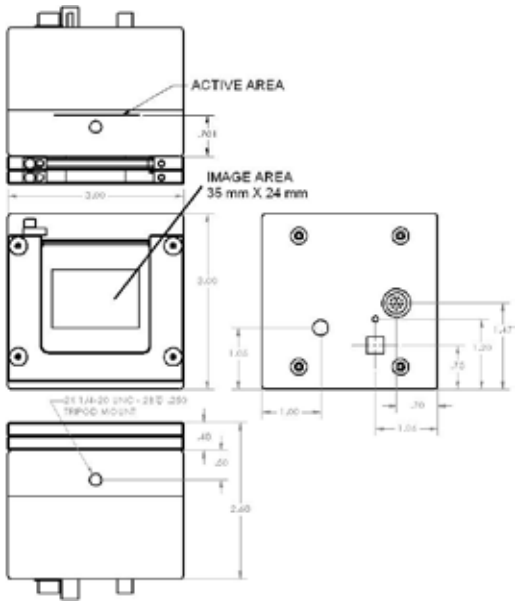
L-Series

Features

- 35mm format for large beams
- 59dB true system dynamic range
- Spectral range: 190 - 1100nm



USB L11059



USB Cameras for use with Laptop or Desktop PC

Item	Specification		
Model	**SP503U**	**SP620U**	**USB L11059**
Application	½" format, slim profile, wide dynamic range, CW & pulsed lasers, adjustable ROI	1/1.8" format, high resolution, wide dynamic range, pulsed lasers, CW YAG, adjustable ROI	36mm x 24mm, 35mm format for large dia. beams, CW & pulsed lasers, ideal for CW YAG, Adjustable ROI
Spectral Response	190 - 1100nm (2)	190 - 1100nm (2)	190 - 1100nm (2)
Active Area	6.3mm W x 4.7mm H	7.1mm W x 5.4mm H	35mm x 24mm
Pixel spacing	9.9µm x 9.9µm	4.40µm x 4.40µm	9.0µm x 9.0µm
Number of effective pixels	640 x 480	1600 x 1200	4008 x 2672
Minimum system dynamic range	64 dB	62 dB	59 dB
Linearity with Power	±1%	±1%	±1%
Accuracy of beam width	±2%		
Frame rates: In 12 bit mode	30 fps at full resolution 60 fps at 320x240	7.5 fps at full resolution 28 fps at 640x480 44 fps at 320x240	3.1 fps at full resolution higher rates with binning and smaller region of interest
Shutter duration	30us to multiple frame times		10us to multiple frame times
Gain control	43:1 automatic or manual control	29:1 automatic or manual control	
Trigger	1. BNC connector accepts positive or negative trigger. LED on camera indicates triggering. Will synchronize with laser repetition rates up to 1KHz. Built in pre-trigger allows synchronization to even sub-nanosecond pulses 2. Same connector can provide trigger out to synch laser. Supports programmable delay on Strobe Out 3. Same connector accepts photodiode trigger (see below)		Supports both Trigger In and Strobe Out
Photodiode trigger	Optional photodiode trigger available: P/N SPZ17005		N/A
Saturation intensity (1)	1.3µW/cm² 2.2µW/cm²	2.2µW/cm²	0.15µW/cm²
Lowest measurable signal (1)	0.5nW/cm²	2.5nW/cm²	0.17nW/cm²
Damage threshold	50W/cm² / 0.1J/cm² with all filters installed for <100ns pulse width(3)		0.15mW/cm²
Dimensions and CCD recess	96mm x 76mm x 16mm CCD recess: 4.5mm below surface	96mm x 76mm x 23mm CCD recess: 4.5mm below surface	83mm x 76mm x 128mm CCD recess: 18.8mm below bezel, 31.75 from ND filter holder
Image quality at 1064nm	Pulsed with trigger sync - excellent Pulsed with video trigger - good CW - poor	Pulsed with trigger sync - excellent Pulsed with video trigger - good CW - good	Pulsed with trigger sync - excellent Pulsed with video trigger - good CW - good
Operation mode	Interline transfer progressive scan CCD		
Software supported	BeamGage		
PC interface	USB 2.0		

Notes:

(1) Camera set to full resolution at maximum frame rate and exposure times, running CW at 632.8nm wavelength. Camera set to minimum useful gain for saturation test and maximum useful gain for lowest signal test.

(2) May be useable for wavelengths below 350nm but sensitivity is low and detector deterioration may occur. Therefore UV image converter is recommended. Although our silicon cameras have shown response out to 1320nm it can cause significant blooming which could lead to significant errors of beam width measurement. We would suggest our XC130 InGaAs camera for these wavelengths to give you the best measurements.

(3) This is the damage threshold of the filter glass of the filters. Assuming all filters mounted with ND1 (red housing) filter in the front. Distortion of the beam may occur with average power densities as low as 5W/cm².

3.2.3.2 190-1100nm Firewire Silicon CCD Cameras

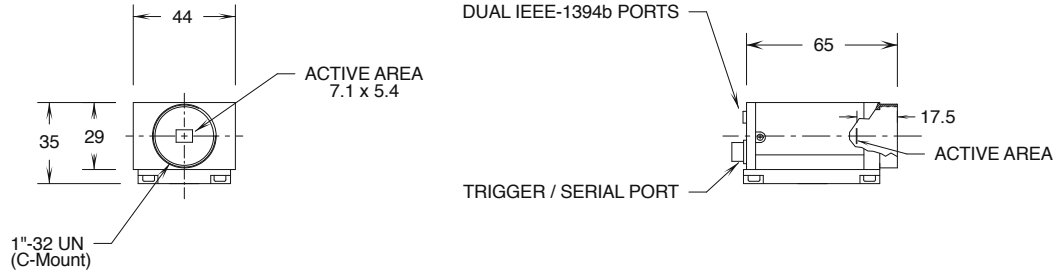
Models GRAS 20

Features

- 61dB true system dynamic range (14 bit with BeamGage)
- High speed electronic shutters
- Exclusive Ultracal available for ISO conforming accuracy
- Flexible external trigger and strobe output for synchronization with laser pulses
- Available with BeamGage software

GRAS 20

GRAS 20/GRAS 20-1550



Firewire Cameras for use with Laptop or Desktop PC

Item	Specification
Model	**GRAS 20**
Application	1/1.8" format, high resolution, CW YAG, adjustable ROI
Spectral Response	190 – 1100nm(3)
Maximum beam size	7.1mm W x 5.4mm H
Pixel spacing	4.4µm x 4.4µm
Number of effective pixels	1600 x 1200
Minimum system dynamic range(1)	61dB
Linearity with Power	±1%
Accuracy of beam width	±2%
Frame rates	15Hz full res; >60Hz depending on ROI(2)
Shutter duration	From 1/frame rate to 1/10,000s. Manual or continuous automatic control
Gain control	0db to 25db Manual control
Trigger	Supports both trigger in and strobe out
Photodiode trigger	Optional photodiode trigger available: ESP-GRAS
Saturation intensity(1)	0.3µW/cm^2
Lowest measurable signa(1)	0.4nW/cm^2
Damage threshold	50W/cm^2 / 1J/cm^2 with all filters installed for <100ns pulse width(4)
Dimensions and CCD recess	35mm x 44mm x 65mm Fixed C-mount
Image quality at 1064nm	Pulsed with video trigger - good Pulsed, sync - excellent CW - good
Operation mode	Interline transfer progressive scan CCD
Software supported	BeamGage
PC interface	IEEE 1394b Firewire
Minimum host system requirements	IEEE 1394b requires 1394b port or PCI-Express or CardBus Slot

Notes:

(1) Camera set to full resolution at maximum frame rate and equivalent exposure times, running CW at 632.8nm wavelength. Camera set to minimum useful gain for saturation test and maximum useful gain for lowest signal test.
(2) The maximum rate depends on the ROI (Region of Interest) size, the bits readout, and the number of cameras on the same bus. The SCOR 20 operates at 7.5Hz 12 bits and 15Hz 8 bits. It operates up to at least 60Hz with a smaller ROI. The frame rate also depends on PC resources.
(3) May be usable for wavelengths below 350nm but sensitivity is low and detector deterioration may occur. Therefore UV image converter is recommended. Although our silicon cameras have shown response out to 1320nm it can cause significant blooming which could lead to significant errors of beam width measurement. We would suggest our XC130 InGaAs camera for these wavelengths to give you the best measurements.
(4) This is the damage threshold of the filter glass of the filters. Assuming all filters mounted with ND1 (red housing) filter in the front. Distortion of the beam may occur.

3.2.3.3 190-1100nm Gig-E Silicon CCD Cameras

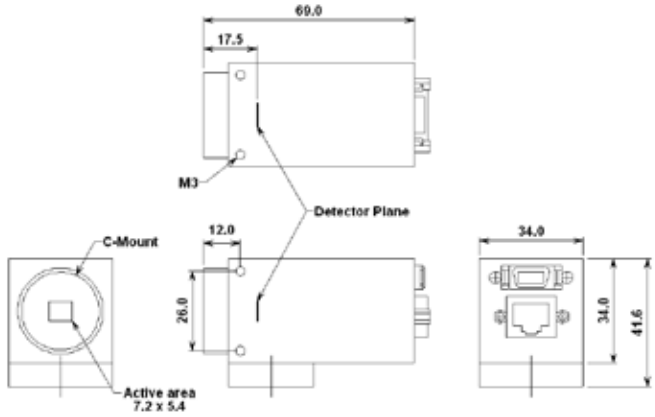
Models Gevicam

Features

- Ethernet compatible
- Network multiple cameras, multiple versions of BeamGage
- Long cable distances
- High speed image acquisition
- External trigger for synchronization with laser pulses

Gevicam

Gevicam



Gig-E Cameras for use with Laptop or Desktop PC

Item	Specification
Model	**Gevicam**
Application	1/1.8" format, high resolution, networkable, long cable distances, adjustable ROI
Spectral Response	190 - 1100nm*
Maximum beam size	7.16mm (H) x 5.44mm (V)
Pixel spacing	4.4µm x 4.4µm
Number of effective pixels	1600 x 1200
Minimum system dynamic range(1)	~57dB full speed, full resolution, min gain
Linearity with Power	±1%
Accuracy of beam width	±2%
Frame rates	17fps @ full resolution /7.5fps optional; faster rates with binning
Shutter duration	60ms @ 17fps; 133ms @ 7.5fps
Gain control	33dB
Trigger	5V TTL 2µsec min, positive pulse, rising edge triggered
Photodiode trigger	N/A
Saturation intensity(1)	0.3µW/cm^2
Lowest measurable signa(1)	0.5lux @ 17fps
Damage threshold	50W/cm^2 / 0.1J/cm^2 with all filters installed for <100ns pulse width(3)
Dimensions and CCD recess	34mm x 34mm x 69mm CCD recess: 17.5mm below surface
Image quality at 1064nm	Pulsed with video trigger - good, Pulsed sync - excellent, CW - good
Operation mode	Inline transfer progressive scan
Software supported	BeamGage - Enterprise
PC interface	Gigbit ethernet
Minimum host system requirements	PC desktop with PCI-Express slot or laptop with PCI-Express/34 slot
Windows OS support	Windows 7 (32/64) or Vista (32/74)

Notes:

(1) Camera set to full resolution at maximum frame rate and equivalent exposure times, running CW at 632.8nm wavelength. Camera set to minimum useful gain for saturation test and maximum useful gain for lowest signal test.
(2) The maximum rate depends on the ROI (Region of Interest) size, the bits readout, and the number of cameras on the same bus. The SCOR 20 operates at 7.5Hz 12 bits and 15Hz 8 bits. It operates up to at least 60Hz with a smaller ROI. The frame rate also depends on PC resources.
(3) May be usable for wavelengths below 350nm but sensitivity is low and detector deterioration may occur. Therefore UV image converter is recommended. Although our silicon cameras have shown response out to 1320nm it can cause significant blooming which could lead to significant errors of beam width measurement. We would suggest our XC130 InGaAs camera for these wavelengths to give you the best measurements.
(4) This is the damage threshold of the filter glass of the filters. Assuming all filters mounted with ND1 (red housing) filter in the front. Distortion of the beam may occur.

3.2.3.4 1440-1605nm Phosphor Coated CCD Cameras For NIR Response

Features

- 1440-1605 nm Wavelengths
- NIR Telecom mode field analysis
- NIR Laser beam analysis

Available Models

- USB models: SP503U-1550
  SP620U-1550
- Firewire models: GRAS20-1550
- Analog Camera: SP-1550M

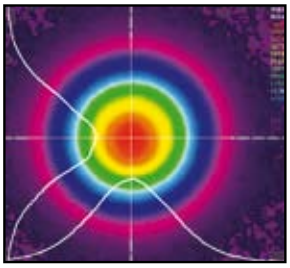
GRAS20-1550

SP503U-1550
SP620U-1550

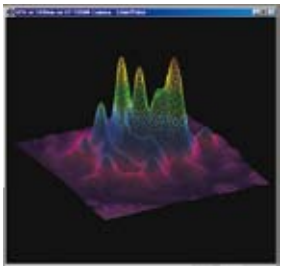
SP-1550M

Phosphor Coating Technology

The up-conversion from NIR to visible light in the 1550 series cameras is nonlinear.
The anti-Stokes phosphor coating produces visible photons at a rate roughly the square of the input signal. This is shown dramatically where the camera total output increases dramatically faster than a linear output shown in the bottom line. The CCD camera saturation in the center of a beam, the up-converted visible signal drops as the square of the input signal. Thus the lower signal wings of a beam are suppressed, resulting in the appearance and measurement of a beam width much smaller than actual.



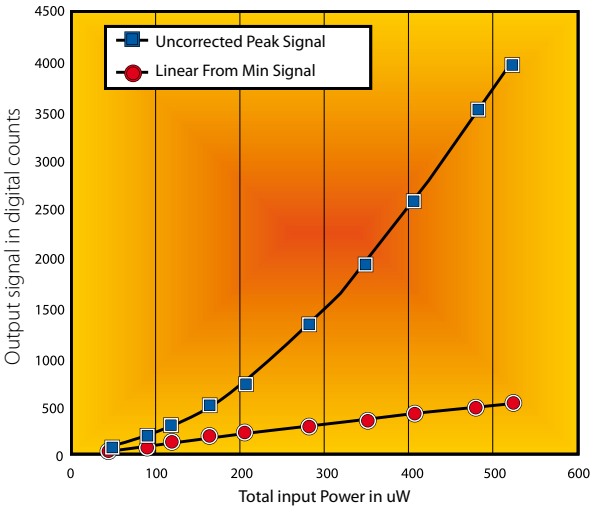
1550nm Fiber Output



1610nm OPO Output

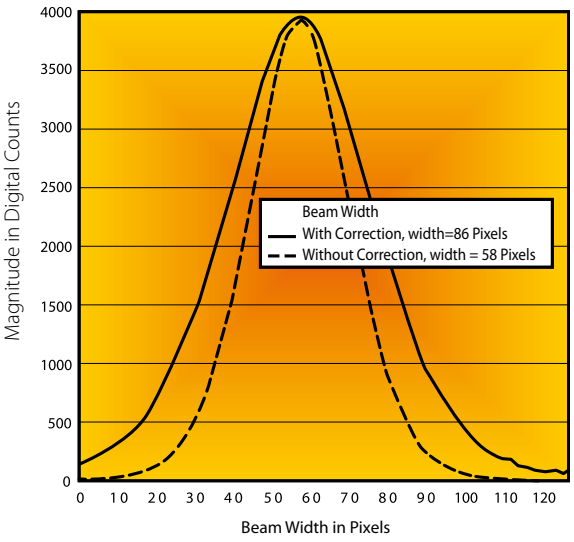
This illustration is a comparison of the cross-section of a beam with and without correction. As seen, the real width of the beam is much greater than would be observed without correction.

Non-Linearity of SP-1550M Camera at 1550nm



Non-linear output of the 1550 series cameras.

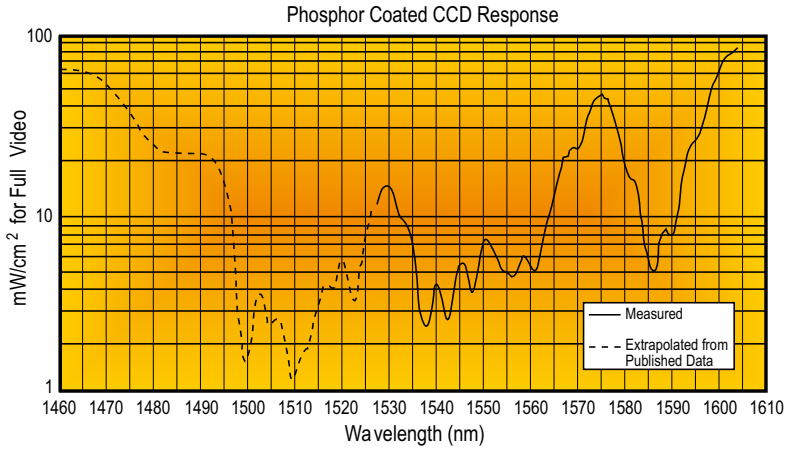
SP-1550M Camera: Comparison of Beam Shape with and without Correction Factor



Cross-section of a fiber beam with and without non-linearity correction.

Wavelength Response

The anti-Stokes up-conversion efficiency is very wavelength dependent. This graph shows the typical spectral response curve of a new, high response coating. As seen, we have calibrated the response from 1527nm to 1605nm. We have extrapolated the shorter wavelength region by comparing our measured response to data published over the entire range.

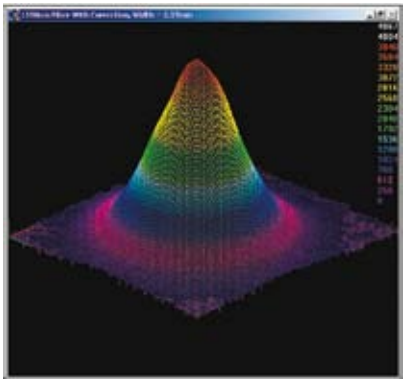


Signal required versus wavelength to achieve camera full signal illumination by anti-Stokes up conversion material.

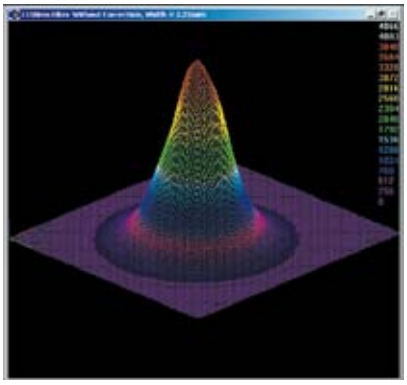
Phosphor Coated Cameras with Spiricon's BeamGage software

Spiricon's engineers have carefully measured the non-linearity of the signal generated by the Phosphor Coated series cameras. The software in the BeamGage incorporates an algorithm to correct for the non-linearity. This illustration shows the linearity obtained, showing in the top line that the low level signals drop linearly, rather than at the square of the input, seen in the lower line.

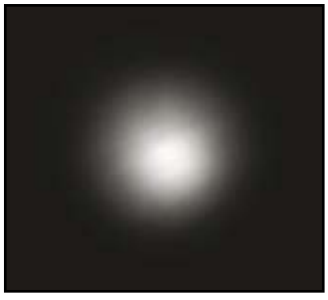
The two photos show the uncorrected and corrected camera beam shape in 3D. See the BeamGage section for additional information on the beam analyzer.



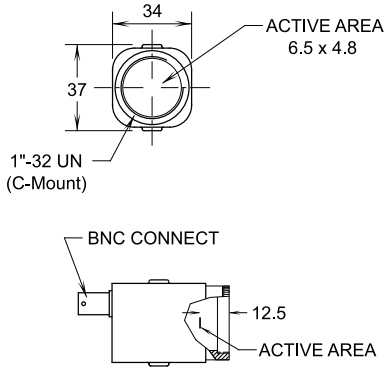
Beam profile of a fiber beam with non-linearity correction.



Beam profile of a fiber beam without non-linearity correction.



SP-1550M; RS-170 monitor display when used without a frame grabber.



Specifications: Phosphor Coated For NIR Response

Model	SP503U-1550	SP620U-1550	GRAS20-1550	SP-1550M
Application	NIR wavelengths, ½" format, low resolution	NIR wavelengths, 1/1.8" format, low resolution, adjustable ROI and binning	NIR wavelengths, 1/1.8" format, adjustable ROI	NIR wavelengths, ½" format
Spectral Response	1440 - 1605nm	1440 - 1605nm	1440 - 1605nm	1440 - 1605nm
Maximum beam size	6.3mm W x 4.7mm H	7.1mm W x 5.4mm H	7.1mm x 5.4mm	4.7mm x 5.4mm
Pixel spacing (1)	9.9µm x 9.9µm	4.4µm x 4.4µm	4.4µm x 4.4µm	8.4µm x 9.8µm
Number of effective pixels	640 x 480	1600 x 1200	1600 x 1200	640 x 480 pixels
Minimum system dynamic range (2)	~30 dB	~30 dB	~30dB	~30dB
Linearity with Power	±5%	±5%	±5%	±5%
Spatial Uniformity	±5%	±5%	±5%	±5%
Accuracy of beam width	±5% for beams larger than 0.6 mm			
Frame rates In 12 bit mode (3)	30 fps at full resolution 60 fps at 320x240	8 fps at full resolution 28 fps at 640x480 44 fps at 320x240	15Hz full res >60Hz with smaller ROI (3)	30 Hz
Shutter duration	30µs to multiple frame times			1/60 to 1/100,000 sec, 9 steps
Gain control	43:1 manual	29:1 manual	0db to 25db Manual control	Manual adjustment
Trigger	Supports both Trigger In and Strobe Out			N/A
Photodiode trigger	Consult Factory		N/A (consult factory)	N/A
Saturation intensity	7mW/cm² at 1550 nm			
Lowest measurable signal	~ 50µW/cm²			
Damage threshold	50W/cm²/0.1J/cm² with all filters installed for <100ns pulse width(4)		70 mW/cm² at 1550 nm	70 mW/cm² at 1550 nm
Dimensions and CCD recess	96X76X16mm; 4.5mm below surface	96X76X28mm; 4.5mm below surface	20mm x 44mm x 58mm Fixed C-mount	37mm x 34mm x 56mm CCD recess from surface 12.5mm, Adjustable
Operation mode	Interline transfer progressive scan CCD		Interline transfer progressive scan CCD	Interline Transfer interlaced CCD
Software supported	BeamGage		BeamGage	
PC interface	USB 2.0		IEEE 1394b	
Host system requirements			IEEE 1394 port or PCI-Express or CardBus Slot	

Notes:

(1) Despite the small pixel size, the spatial resolution will not exceed 50µm due to diffusion of the light by the phosphor coating.
(2) Signal to noise ratio is degraded due to the gamma of the phosphor's response. Averaging or summing of up to 256 frames improves dynamic range by up to 16x = +24dB.
(3) In normal (non-shuttered) camera operation, the frame rate is the fastest rate at which the laser may pulse and the camera can still separate one pulse from the next. With electronic shutter operation, higher rate laser pulses can be split out by matching the laser repetition to the shutter speed.
(4) This is the damage threshold of the filter glass of the filters. Assuming all filters mounted with ND1 (red housing) filter in the front. Distortion of the beam may occur with average power densities as low as 5W/cm².

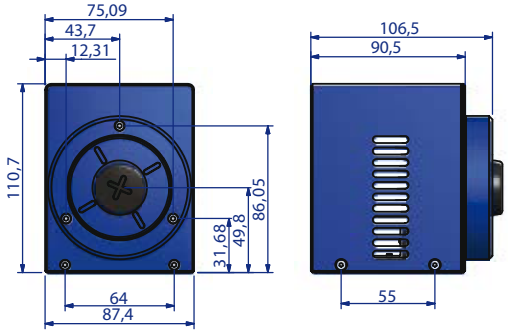
3.2.3.5 900-1700nm - InGaAs NIR Cameras

Models XC-130 100Hz

Features

- NIR performance at room temperature
- High resolution InGaAs array: 320x256
- 60dB true system dynamic range
- Exclusive Ultracal for ISO conforming accuracy
- Available with BeamGage software

XEVA 100Hz



USB Cameras for use with Laptop or Desktop PC

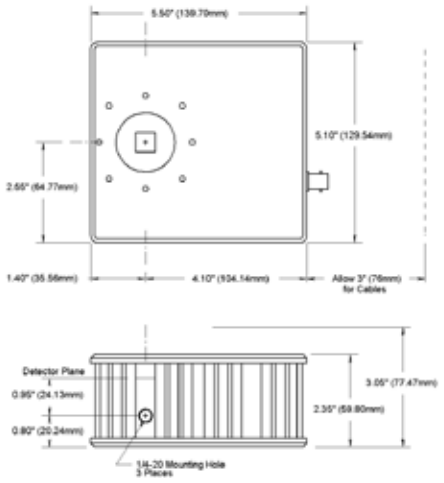
Model XEVA XC-130	Description
Application	NIR wavelengths, high resolution, ROI and binning
Spectral response	900-1700nm (consult factory for other options)
Element pitch	30µm square
Number or elements	320 x 256
Area	9.6 x 7.6mm
Lens	C-mount, (Optional)
Minimum system dynamic range	low gain 68dB, high gain 60dB
Frame rate	100 Hz (1)
Non-uniformity correction	2-Point correction plus bad pixel correction, NUC files provided
Snap-shot mode	Via external TTL trigger, cable provided
Exposure control	1us to 400 sec in Low Gain mode
Imager Cooling	Thermoelectric cooler plus forced convection
Ambient operating temperature	0 - 50° C
Dimensions, mm, HxWxD	111 x 87 x 107 mm
Weight, camera head	approx. 1.8 kg
Software supported	BeamGage
PC interface	USB 2.0, special cable provided
Note:	(1) The uncorrected rate, final corrected rate will be less.

3.2.4 13-355nm and 1.06-3000µm - Pyroelectric Array Camera

Pyrocam™ III Series

Features

- Spectral ranges available from 13 to 355 nm and 1.06 to >3000 µm
- Image CO_2 lasers, telecom NIR lasers and other infrared sources out to Far IR THz sources
- Solid state array camera with 1000:1 linear dynamic range for accurate profiling
- Integrated chopper for CW beams and thermal imaging
- Versatile Firewire interface
- Interchangeable windows available for a variety of applications
- Image Viewer utility presents 3D isometric plots, 2D color contour plots and grayscale, among other views
- Includes BeamGage Laser Beam Analysis Software for extensive quantitative analysis and image display



Spiricon has been the world leader in the manufacture of pyroelectric solid-state detector arrays and cameras. For over 25 years the Pyrocam™ has been the overwhelming camera of choice for Laser Beam Diagnostics of IR and UV lasers and high temperature thermal imaging. Precision, stability, reliability, and versatility have become its proud heritage.

The Pyrocam™ III offers easy Windows® camera setup, direct Windows quantitative and image display, 14 bit digitizer, versatile Firewire® PC interface, an integral chopper for CW beams and thermal imaging, and many other enhanced features.

See Your Beam As Never Before

The Pyrocam™ III camera creates clear and illuminating images of your laser beam profile. Displayed in 2D or 3D views, you can immediately recognize beam characteristics that affect laser performance and operation. This instantly alerts you to detrimental laser variations. Instantaneous feedback enables timely correction and real-time tuning of laser parameters. For example, when an industrial shop foreman saw the CO_2 laser beam profile in Figure 1 he knew immediately why that laser was not processing materials the same as the other shop lasers, with the profile shown in Figure 2.

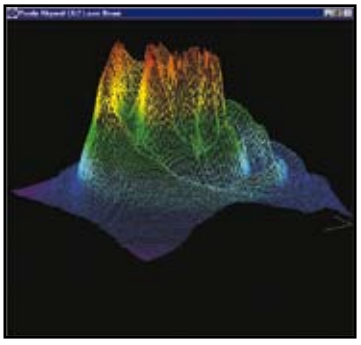


Fig. 1. Industrial CO_2 laser performing inconsistent processing.

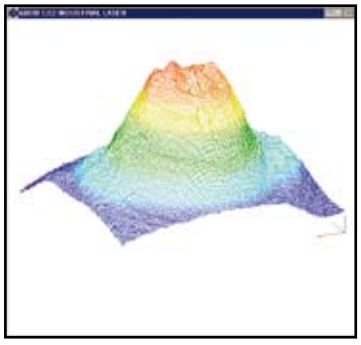


Fig. 2. Industrial CO_2 laser performing specifed processing.

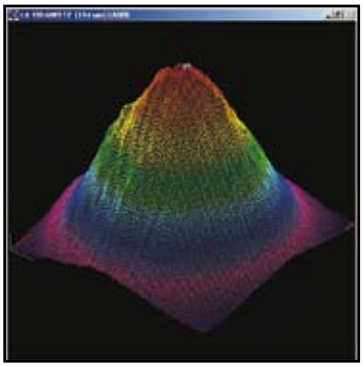
Pulsed and CW Lasers

The Pyrocam™ III measures the beam profile of both pulsed and CW lasers. Since the pyroelectric crystal is an integrating sensor, pulses from femtosecond to 12.8ms can be measured. The pyroelectric crystal only measures changes in intensity, and so is relatively immune to ambient temperature changes. Because CW laser beams must be chopped to create a changing signal, the Pyrocam™ III contains an integral chopper as an option.

Measuring Terahertz Beam Profiles

Spiricon's Pyrocam™ III pyroelectric camera is an excellent tool for measuring THz lasers and sources. The coating of the crystal absorbs all wavelengths including 1µm to over 3000µm (0.1THz to 300THz). For THz sources the sensitivity of the Pyrocam™ III is relatively low, at about 300mW/cm^2 at full output. With a S/N of 1000, beams of 30mW/cm^2 are easily visible.
In addition, with Spiricon's patented Ultracal baseline setting, multiple frames can be summed to "pull" a signal out of the noise. Summing 256 frames enables viewing of beams as low as 1-2mW/cm^2.

With Terahertz research suddenly being a central topic of interest, the Pyrocam™ III becomes an invaluable aid in this exciting research. Otherwise, scientists working on Terahertz research have no easy way to characterize the profile, or energy distribution, of their lasers or sources.



THz laser beam
at 0.2THz (1.55mm) 3mW input power;
19 frames summed.

Broad Wavelength Response

The Pyrocam™ III detector array has a very broadband coating which enables operation at essentially all IR and UV laser wavelengths. The curve ends at 100nm in the UV, but X-ray operation has been observed. Likewise the curve ends at 100µm in the far IR, but the camera has been used at >3000µm.

Thus you can use the Pyrocam™ III in the near IR for Nd:YAG lasers at 1.06µm, and for infrared fiber optics at 1.3µm and 1.55µm. Use the Pyrocam™ III for HF/DF lasers near 4µm and for Optical Parametric Oscillators from 1 µm to 10µm. It measures Free Electron Lasers between 10µm and 3000µm.
The Pyrocam™ III is extremely useful in the UV from 355nm to 157nm for Excimer lasers and for tripled or quadrupled Nd:YAG lasers. The detector is stable under UV illumination, without the deterioration experienced by CCD cameras. (The pyroelectric detector operates in the visible spectrum, and can see the alignment HeNe used with CO_2 lasers. However, spurious response from the underlying silicon multiplexer creates undesirable performance, and the camera is not recommended for quantitative visible measurements).

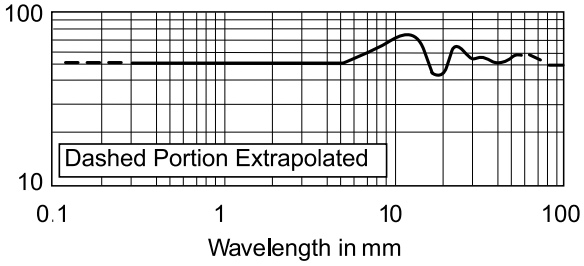
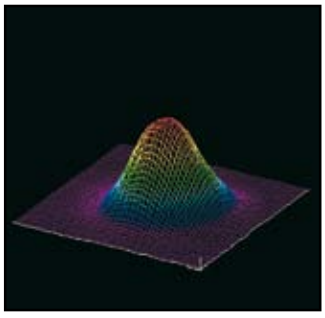
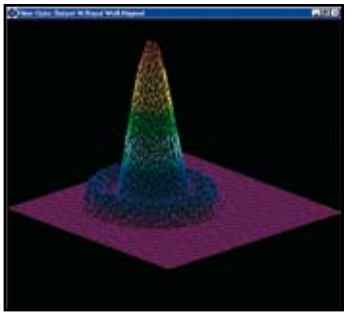


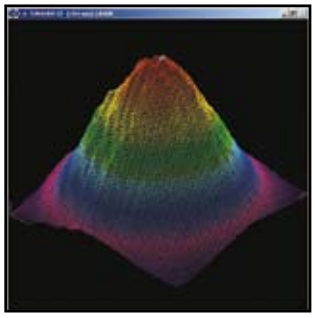
Fig. 6. Spectral response of Pyrocam™ III detector array without window.



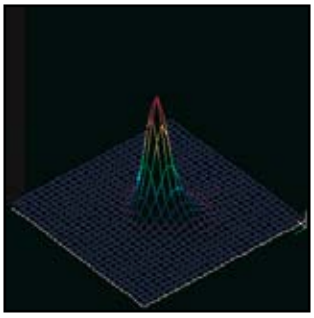
Er:YAG laser at 2.9µm.



Output of infrared fiber optic.



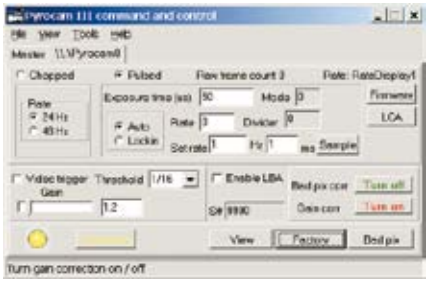
THz laser beam at 1.6THz (184µm).



Free Electron laser at 100µm.

Windows® PC Interface

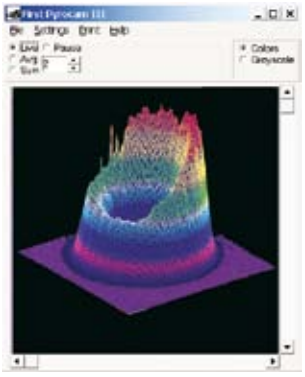
The Pyrocam™ III Windows application incorporates setup software to control all functions of the camera, such as pulsed versus chopped operation, gain, and background reference subtraction, eliminating all controls from the camera housing.



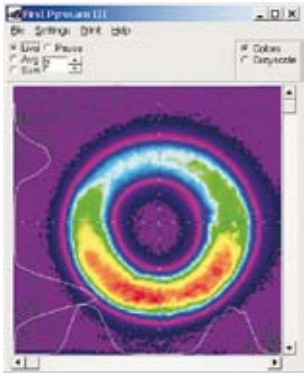
Pyrocam™ III Windows setup menu.

Windows Image Viewer

A Windows viewer application enables viewing of the laser beam in a number of modes, including 3D isometric plots, 2D color contour plots, and gray scale for thermal imaging. This application enables stand-alone operation of the camera independent of any other software. Nevertheless, the Spiricon BeamGage beam analysis software provides many additional features and capabilities not incorporated with the camera.



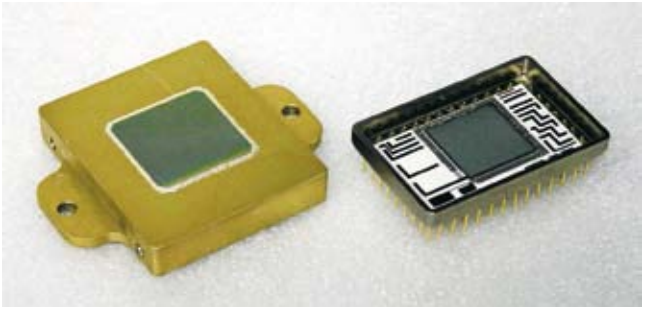
Composite Excimer LASIK beam profile at 193nm.



Composite Excimer LASIK beam profile in 2D display.

Hybrid Integrated Circuit Sensor

The Pyrocam™ III consists of a $LiTa0_3$ pyroelectric crystal mounted with indium bumps to a solid-state readout multiplexer. This sensor, developed for the Pyrocam I, has proven to be the most rugged, stable, and precise IR detector array available.
Light impinging on the pyroelectric crystal is absorbed and converted to heat, which creates charge on the surface. The multiplexer then reads out this charge onto the video line. For use with short laser pulses, the firmware of the camera creates a very short electronic shutter to accurately capture the thermally generated signal.



Pyrocam™ III sensor array and window assembly

State-Of-The-Art Electronics

The camera features a 14 bit A/D converter which digitizes deep into the camera noise. This enables reliable measurement and analysis of both large signals and low level signals in the wings of the laser beam. Fourteen bit digitizing also enables accurate signal summing and averaging to pull weak signals out of noise. This is especially useful with fiber optics at 1.3µm and 1.55µm, and in thermal imaging.

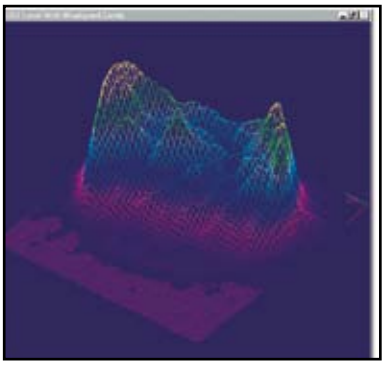
The Pyrocam™ III camera electronics incorporates 2 Firewire® (IEEE 1394A) interface ports. Multiple Pyrocam IIIs can be daisy chained together using the 1394 cabling.

New Housing & Chopper

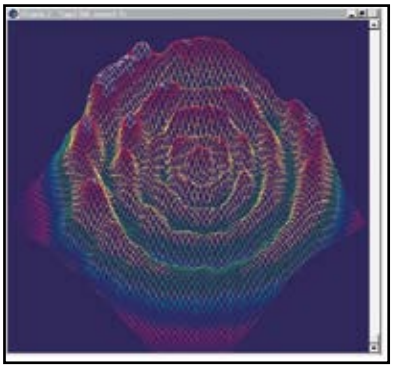
The Pyrocam™ III incorporates a new compact housing measuring only 5.5" high by 5.1" wide, and 2.5" deep in the direction of the beam path. This allows the camera to be inserted into smaller spaces on the optical table. It also makes the camera useful as a portable camera for thermal imaging and on-site field service of laser systems. The Pyrocam™ III integral focal plane chopper helps keep the camera head compact.

Applications Of The Pyrocam™ III

The Pyrocam™ III is an ideal camera for use in scientific laboratory investigation of laser beams. This includes physics, chemistry, and electronic system designs. As an example, the photos below show a research CO_2 laser and a research Nd:YAG laser, both with cavity misalignment.
The camera is also useful in product engineering of CO_2 and other infrared lasers. The Pyrocam™ III is an integral part of the assembly lines of many CO_2 laser manufacturers. Integrators of systems are using the Pyrocam™ sensor to make sure that optical systems are aligned and operating properly.

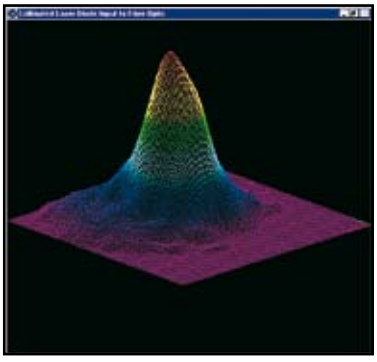


CO_2 laser with cavity misalignment.

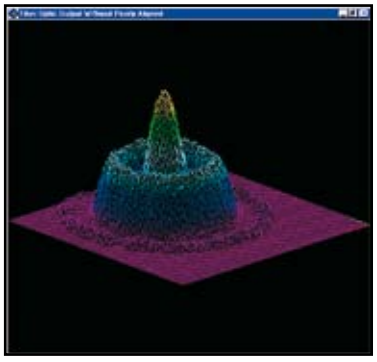


Nd:YAG laser with cavity misalignment.

There are many medical applications of the Pyrocam™ III, such as the analysis of excimer lasers used for eye surgery. In many cases these lasers need alignment to ensure that the eye surgery is performed as expected. Other medical IR lasers perform dermatology, for which the uniformity of the beam profile must be assured.
Fiber optic communications, at 1.3µm and 1.55µm make significant use of the Pyrocam™ III for analyzing the beams being emitted, as well as analyzing properties of the beams before launching them into fibers. The greater stability of the Pyrocam™ III make it a good choice over other cameras operating at telecommunication wavelengths.



CO_2 laser with cavity misalignment.

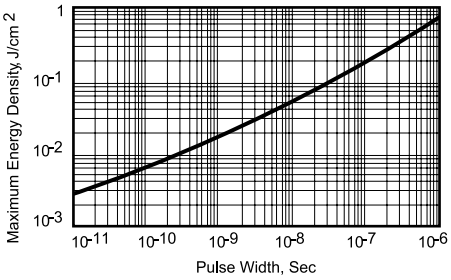


Nd:YAG laser with cavity misalignment.

The Pyrocam™ III is becoming an essential tool in the maintenance of industrial infrared lasers, especially CO_2. The Pyrocam™ III replaces non-electronic mode burns and acrylic blocks by providing higher definition electronic recording of data, and analysis of short term fluctuations. The Pyrocam™ III is superior to other electronic methods of measuring CO_2 lasers because the entire beam can be measured in a single pulse, and additional measurements made in real-time. This ensures that the beam did not change during the measurement.

Detector Damage Threshold

The Pyrocam™ III sensor is capable of operation with intensities about 106 times greater than CCD cameras. This makes the camera ideal for use with high power lasers, as less attenuation is required. Nevertheless, pulsed lasers with fluence too high can evaporate the absorbing front electrode.



Pulsed damage threshold of pyroelectric detector coating.

As shown the damage threshold increases with pulse width. With nanosecond and longer pulses, detector saturation occurs before damage. With shorter pulses it helps to increase the camera amplifier gain so that electronic saturation occurs before damage.

The sensor can be damaged by excessive CW power, which causes crystal cracking. Very few Pyrocam™ III detectors have been damaged by CW power, but some have been ablated by high peak pulse energy.

GENERAL SPECIFICATIONS FOR PYROCAM™ III

Application	UV and IR
Spectral response	13 - 355nm
	1.06 - 3000µm
Interchangeable windows	See selection in Ordering Information section
Active area	12.4mm x 12.4mm
Element spacing	100µm x 100µm
Number of elements	124 x 124
Pixel size	85µm x 85µm
CHOPPED CW OPERATION	
Chopping frequencies	24Hz
Optional chopper	48Hz
Sensitivity (RMS noise limit)	220 nW/pixel (24Hz)
	320 nW/pixel (48Hz)
	2.2 mW/cm² (24Hz)
	3.2 mW/cm² (48Hz)
	45 nW/Hz1/2/pixel (1Hz)
Noise equivalent power (NEP)	2.2W/cm²(24Hz)
Saturation power	3.2W/cm² (48Hz)
Damage total power	
Over entire array	2W
Power density	8W/cm²
PULSED OPERATION	
Laser pulse rate	Single-shot to 1000Hz
Pulse width	1fs - 12.8ms
Sensitivity (peak noise limit)	7nJ/pixel
	70µJ/cm²
Saturation energy	10mJ/cm²
Damage threshold	20mJ/cm² (1ns pulse)
	600mJ/cm² (1 µs pulse)
OPERATING CONNECTIONS AND CONDITIONS	
Power	120/230 VAC
	60/50Hz External Supply
Operating temperature	5°C to 50°C
PHYSICAL DIMENSIONS	
Case Dimensions	140mm H X 130mm W X 62mm D
Detector Position	Centered in width
	35.6mm from bottom
	15.2mm behind front cover (without included C-mount attached)
Weight	1.52Kg
MEASUREMENTS PERFORMED BY THE WINDOWS IMAGE VIEWER	
Total power or energy in digital counts or calibrated in software	
Peak power or energy in digital counts or calibrated in software	
Peak location in µm	
Centroid location in µm	
Diameter at 1/e2 points in µm	
X & Y Knife edge beam widths in µm	
USING BEAMGAGE	
Extensive set of quantitative and image display capabilities. See BeamGage data sheet.	

FEATURES

- 14 bit digital output in CW, 13 bit digital output in pulsed
- More critical A & B grading criteria

Grade A Up to 50 bad pixels, all correctable
No uncorrectable clusters

Grade B Up to 100 bad pixels
No uncorrectable clusters within the 70% central area, no more than 2 outside

- Compact Head 5.53"HX5.13"WX2.53"D
- Internal integrated focal plane chopper for CW (24 & 48Hz). No separate controller
- Lens mount and internal focal plane chopper for IR imaging
- Two Firewire® interface ports to PC computer (IEEE 1394a)

GENERAL SPECIFICATIONS FOR PYROCAM™ III

FEATURES
▪ Firewire to PCI adapter
▪ Windows image viewer
2D and 3D beam display
Readout externally calibratable for energy or power
Frame averaging and summing for low level signal analysis
Data logging
Manual gain setting
Plus calculations previously provided
X & Y width
Centroid location
Peak location
Total power or energy in digital counts
▪ Windows setup menu (control console - no buttons or knobs, more user friendly)
▪ High speed, up to 1kHz standard
▪ Automatic lock in to pulse trigger rate
▪ Programmable exposure time (to reduce signal loss from thermal spread) 50µs to 12.8ms in 50µs increments
▪ Slider for fine adjustment gain settings; 1X to 10X CW, 6X Pulse
▪ User enabled bad pixel correction
▪ Separate bad pixel correction for pulsed and CW
▪ User enabled gain correction - separate for pulsed and CW
▪ Internet field upgradeable firmware
▪ Interface to 3rd party software via ActiveX
▪ Export images in .bmp or ASCII file format

Ordering Information

Item	Description	P/N
Pyrocam III Beam Profiler Systems		
PY-III-P-A	Pyroelectric array detector, pulsed only, Grade A, two FireWire ports, and basic viewer software. BeamGage Standard included. To complete this order, you must add an Interchangeable Window part number to accompany this system (see below).	SP90090
PY-III-P-B	Pyroelectric array detector, pulsed only, Grade B, two FireWire ports, and basic viewer software. BeamGage Standard included. To complete this order, you must add an Interchangeable Window part number to accompany this system (see below).	SP90091
PY-III-C-A	Pyroelectric array detector, chopped and pulsed, Grade A, two FireWire ports, and basic viewer software. BeamGage Standard included. To complete this order, you must add an Interchangeable Window part number to accompany this system (see below).	SP90092
PY-III-C-B	Pyroelectric array detector, chopped and pulsed, Grade B, two FireWire ports, and basic viewer software. BeamGage Standard included. To complete this order, you must add an Interchangeable Window part number to accompany this system (see below).	SP90093
Interchangeable Windows for Pyrocam III (one included free with the purchase of a Pyrocam III Beam Profiler System)		
PY-III-W-BK7-1.064	Pyrocam III Window BK7 A/R coated to 1064nm	SP90101
PY-III-W-Si-1.05-2.5	Pyrocam III Window Silicon A/R coated to 1.05 - 2.5µm	SP90102
PY-III-W-Si-2.5-4	Pyrocam III Window Silicon A/R coated to 2.5 - 4µm	SP90103
PY-III-W-Ge-3-5.5	Pyrocam III Window Germanium A/R coated to 3 - 5.5µm	SP90104
PY-III-W-Ge-10.6	Pyrocam III Window Germanium A/R coated to 10.6µm	SP90105
PY-III-W-Ge-8-12	Pyrocam III Window Germanium A/R coated to 8 - 12µm	SP90106
PY-III-W-ZnSe-10.6	Pyrocam III Window Zinc Selenide A/R coated to 10.6µm	SP90107
PY-III-W-ZnSe-2-5	Pyrocam III Window Zinc Selenide A/R coated to 2 - 5µm	SP90108
PY-III-W-Poly-THz	Pyrocam III Window Polyethylene uncoated for Tera-Hz wavelengths	SP90208

3.2.4.1 YAG Focal Spot Analyzer

- Image focal spots down to 25µm in size
- For laser powers up to 400W (additional external ND filters required)
- Measure how focal distance shifts with power
- Can measure systems with focal length as short as 50mm
- Modular design allows flexibility in use
- C-mount, compact laser beam sampler/attenuator for camera based laser beam profiling systems
- High damage threshold optics for measuring energetic sources
- Produces undistorted sample of laser under test
- Adjustable attenuation maximizes system dynamic range
- Up to 1 x 10^{-10} attenuation available (without external filters)

Measure the focal spot of a relatively high power laser, in particular a YAG laser. The average power can be from <1 to 400 Watts and the focal spot can be as small as 25µm. The FSA can also be used to measure how the focal spot shifts with power.

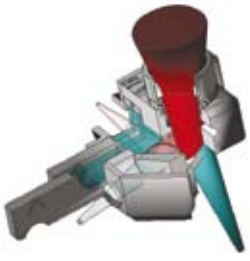
The lasers focal length from the lens to the focal spot is usually on the order of 70 to 120mm. The YAG FSA assembly adds a negative lens to the LBS-300 beam splitter assembly to increase the focal path and at the same time enlarge the image. Several focal length lenses are available to accommodate different host system focal paths. The FSA includes; user selectable negative lens, 2 beam splitters, a removable beam block on the 2nd splitter, and user selectable attenuation filters prior to the beam entering the camera. An excel spreadsheet is downloadable from our website that calculates which lenses are available to use for your application, how far to mount the FSA from your focusing lens in order to see the focal spot and what the magnification of the image will be.

Operation:

The FSA is mounted to the camera as shown. Then the assembly is placed below the final focusing lens of the laser at the recommended distance. The focal spot is found by moving the assembly closer and farther from the beam until the smallest spot size is seen. The exact magnification factor (usually 2-3 times) is calculated by moving the stage holding the FSA assembly a given lateral distance and seeing how far the centroid of the focal spot moves in the beam profiling software. This scaling factor is then entered into the software. In order to find focal spot shift with laser power, simply find focal spot at one power, change the power and measure how far the stage has to be moved up or down to get to the smallest beam size again.

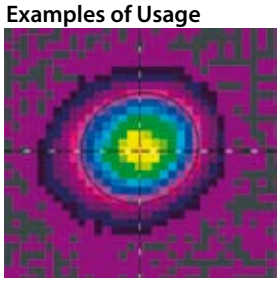
Incoming Beam
Camera
Negative lens
LBS-300
2nd Output Beam; built-in beam block
1st Output Beam; either to power meter or to Beam Dump
User selectable ND filters for attenuating input to the camera

Focal Spot Assembly Looking from camera mounting position

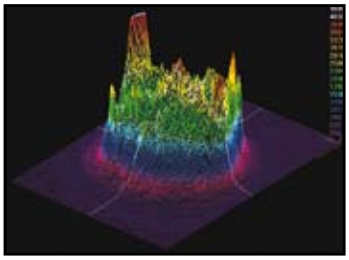


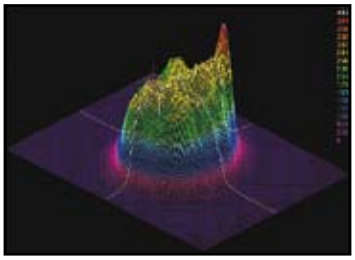
Focal Spot Assembly showing various beam paths

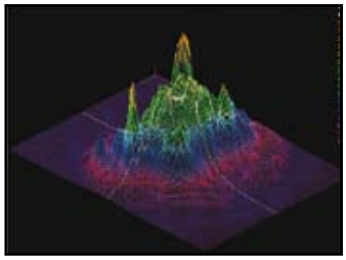
Examples of Usage



65µm diameter focal spot







Focal spot shape changing with laser power level

Specifications

Model	YAG Focal Spot Analyzer
Wavelength	1064nm
Wedge Material	BK7
Wedge Coating	AR ≤1%
Clear aperture	17.5mm
Wedge ND value, each	ND ≥2
ND Filters	Bulk ND
ND Values, nominal	0.3, .7, 1.0, 2.0, 3.0, 4.0 (Red holders)
Filter Slides	3
Filter Damage (1)	50 W/cm² 1J/cm², 10ns pulse
Negative Lens To add FSA capability	FSA-50Y
	-50mm YAG
	FSA-100Y
	-100mm YAG
	FSA-125Y
	-125mm YAG
	FSA-150Y
	-150mm YAG
	FSA-200Y
	-200mm YAG
Accessories	
Variable Wedge ND Filter kit	WVF-300
Beam Dumps	BD-040-A, 40 Watts Max Power, Air Cooled
	BD-500-W, 500 Watts Max Power, Water Cooled

Note: (1) ND bulk absorbing filters damage threshold is 50W/cm² but should be used at <5W/cm² to avoid thermal lensing effects.

Ordering Information

Item	Description	P/N
YAG Focal Spot Analyzer		
YAG Focal Spot Analyzer assembly requires 1 each LBS-300-NIR and 1 each Negative Lens		
LBS-300-NIR	Beam splitter and attenuators; beam split 2 times	SP90185
FSA-50Y	Negative lens; -50 mm YAG	SP90187
FSA-100Y	Negative lens; -100 mm YAG	SP90188
FSA-125Y	Negative lens; -125 mm YAG	SP90189
FSA-150Y	Negative lens; -150 mm YAG	SP90190
FSA-200Y	Negative lens; -200 mm YAG	SP90191
Accessories		
WVF-300	ND filters; variable wedge. Replaces fixed value filter slides	SP90195
BD-040-A	Beam Dump; 40 Watts max. power, air cooled	SP90192
BD-500-W	Beam Dump; 500 Watts max. power, water cooled	SP90193

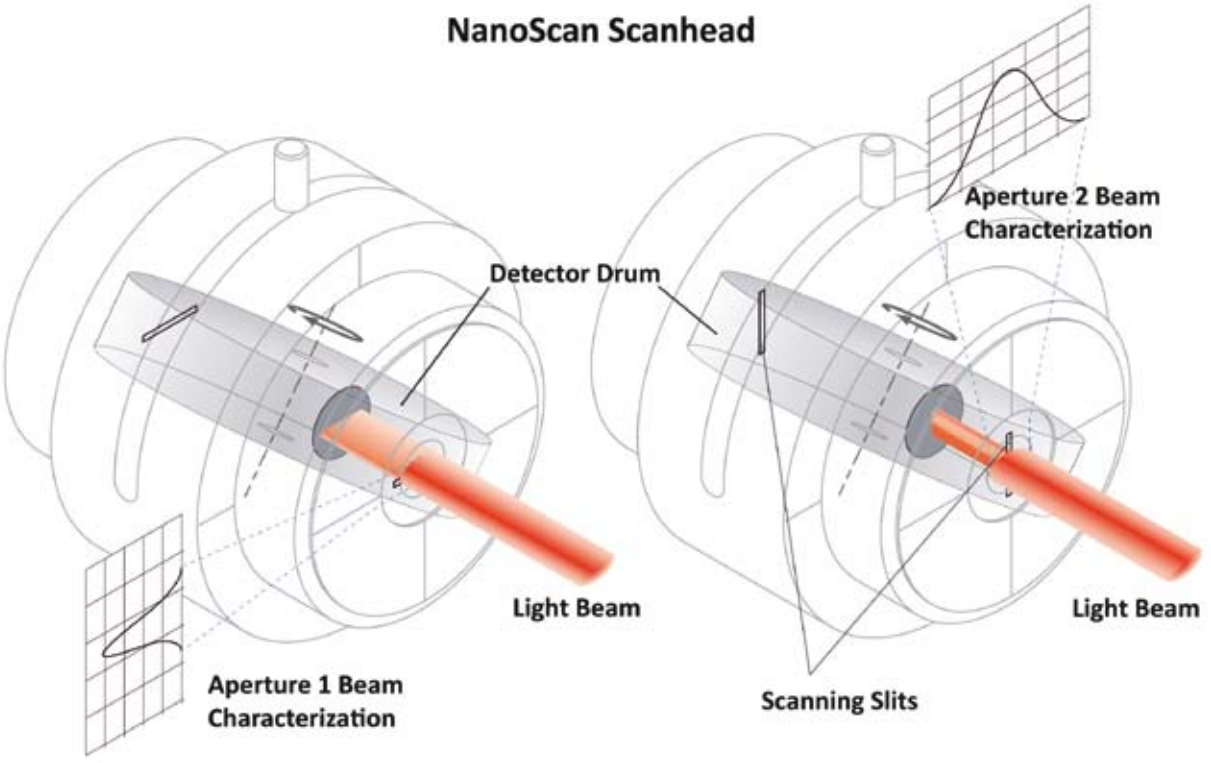
3.3 Introduction to Scanning-Slit Profilers

The scanning slit beam profiler moves two narrow orthogonal slits in front of a linear photo-detector through the beam under analysis. Light passing through the slit induces a current in the detector. Thus, as the slit scans through the beam, the detector signal is linearly proportional to the spatial beam irradiance profile integrated along the slit. A digital encoder provides accurate slit position. The photo-induced current signal is digitized and analyzed to obtain the beam profile in both X and Y from the two orthogonal slits.

The slit apertures act as physical attenuators, preventing detector saturation for most beam applications. High dynamic range amplification allows operation over many orders of magnitude in beam power.

From these profiles, important spatial information such as beam width, beam position, beam quality, and other characteristics are determined. This technique can accommodate a wide variety of test conditions. Because slit scanners measure beams at high powers with little or no attenuation, they are ideal to profile beams used in material processing.

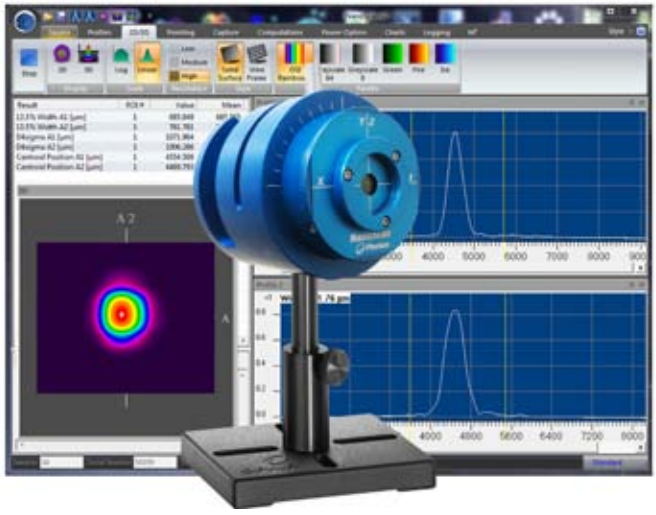
Carbon dioxide (CO2) lasers are widely used in materials processing, and have a 10.6 micron wavelength that cannot be profiled with most cameras. Slit scanners, therefore, provide an convenient means of measuring high-resolution CO2 lasers with powers up to and exceeding 1000 watts.



3.3.1 NanoScan 2

Scanning Slit Beam Profiler For High Accuracy Dimensional Measurementt

NanoScan 2 now features direct USB2 connection to the PC and is available to measure CW and pulsed beams across the spectral range from UV to infrared up to 1800nm. Coupled with the new NanoScan 2 software package that allows configuration of the user interface displays, the Photon NanoScan 2 scanning slit profilers provide major enhancements to the ease-of-use and flexibility that customers have come to expect with its predecessors, the world-renowned NanoScan and BeamScan.



Capabilities

NanoScan 2 is a PC-based instrument for the measurement and analysis of optical beam spatial profiles in accordance with ISO standards. Beam profiles are measured using the International Standard ISO 11146. Scanheads can also measure power in accordance with ISO 13694.

NanoScan uses moving slits, one of the ISO Standard scanning aperture techniques. Measurement is possible for beam sizes from microns to centimeters at beam powers from microwatts to over kilowatts, often without attenuation. Detector options (silicon or germanium) allow measurement at wavelengths from the ultraviolet to the infrared.

The NanoScan2 digital controller has 16-bit digitization of the signal for enhanced dynamic range up to 35dB$_{power}$ optical. With the accuracy and stability of the beam profile measurement you can measure beam size and beam pointing with a 3-sigma precision of several hundred nanometers. The software controllable scan speed and a "peak-connect" algorithm allows the measurement of pulsed and pulse width modulated lasers with frequencies of 20kHz and higher*. The ability to alter the drum speed also helps to increase the dynamic range allowing a much larger operating space for any given scan head (see operating space charts for a graphic explanation).

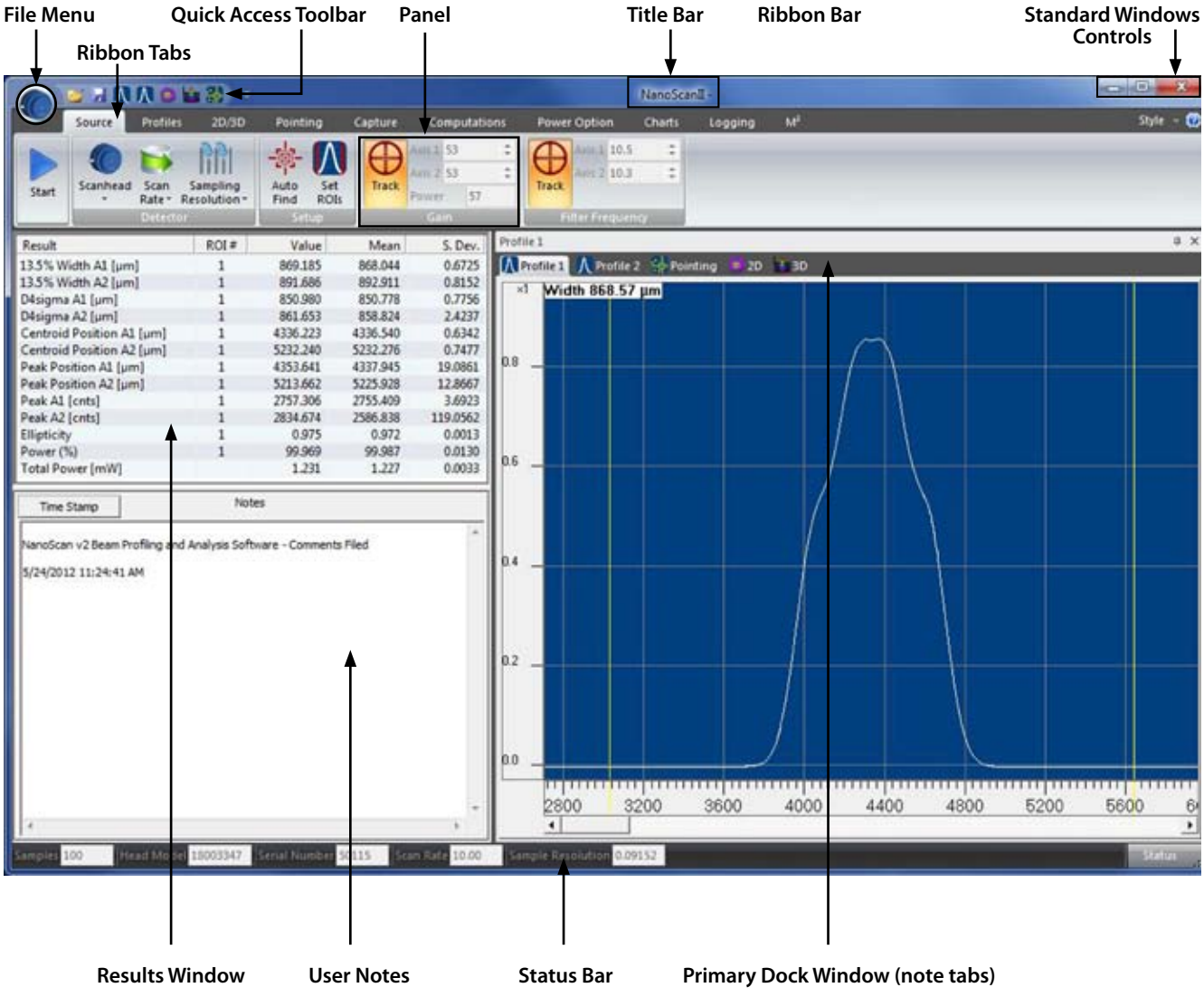
Benefits

- All NanoScan systems are calibrated to a NIST traceable source to ensure the ultimate in accuracy.
- The software finds a beam in less than 0.3 seconds and displays real-time updates up to 20Hz.
- The Z-axis datum plane of the NanoScan is known to ±25µm making the locating of beam waist position simple and accurate.
- Along with the ability to measure pulsed beam diameters, the NanoScan accurately measures and reports the pulse frequency of the laser, ensuring that the pulsed beam measurements are stable and accurate.
- The sampling interval for beam measurements is adjustable to as little as 5.7nm, providing the extreme accuracy required to measure very small beams.
- Profile averaging and rolling averages are available to improve signal to noise.
- NanoScan software has built-in capability to control a mechanical linear stage for measurement of beam caustic.
- Software has a built-in M2 Wizard to assist in making manual propagation ratio measurements.
- Time charts allow any beam result to be charted over time.
- Results logging to text files.
- Relative power meter measurements.
- Optional ActiveX Automation commands with samples of automation programs for Excel VBA, LabView and Visual Basic.net.

*The minimum frequency is a function of the beam size and the scan speed. This is a simple arithmetic relationship; there must be a sufficient number of pulses during the time that the slits sweep through the beam to generate a meaningful profile. Please refer to Photon's Application Note, Measuring Pulsed Beams with a Slit-Based Profiler.

New Configurable User Interface

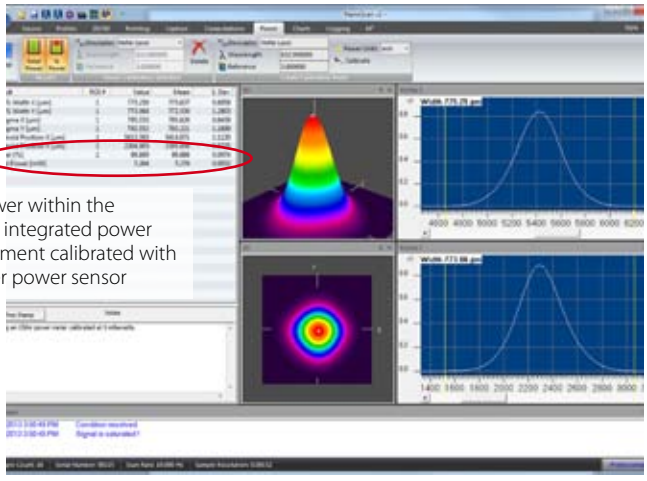
In addition to new hardware, the NanoScan2 has an updated integrated software package for the Microsoft Windows Platform, which allows the user to display any results windows on one screen. The software can select up to 16 regions-of-interest to allow the simultaneous measurement of up to 16 individual beams. The NanoScan 2 software comes in two versions, STD and PRO. The NanoScan 2 pro version of the software includes ActiveX automation for users who want to integrate the NanoScan into OEM systems or write their own user interface screens. The NanoScan into OEM systems or write their own user interface screens.



Integrated Power Meter

The silicon and germanium NanoScan2 systems now come with an integrated 200mW power meter. The relative power meter provides 1.5% correspondence to a user-supplied measurement when configured in the same geometry as calibrated. It comes with a quartz attenuator window that provides a uniform response across a broad wavelength range.

The power meter screen in the software shows both the total power and the individual power in each of the beams being measured.



% of power within the aperture integrated power measurement calibrated with customer power sensor

Available Detectors

The NanoScan 2 is available with either silicon or germanium to cover the light spectrum from UV to infrared. The scan heads are available in several sizes, apertures and slit dimensions. See the table for available configurations.

NanoScan Scanhead Model	Si/3.5/1.8µm	Si/9/5µm	Si/9/25µm
Wavelength	190nm - 950nm	190nm - 950nm	190nm - 950nm
Detector	Silicon	Silicon	Silicon
Entrance Aperture	3.5mm	9mm	9mm
Slit Size	1.8µm	5µm	25µm
1/e² Beam Diameter Range[1]	7µm – ~2.3mm	20µm – ~6mm	100µm – ~6mm
Spatial Sampling Resolution	5.3nm – 18.3µm	5.3nm – 18.3µm	5.3nm – 18.3µm
Profile Digitization	16 bit	16 bit	16 bit
Scan Frequency	1.25, 2.5, 5, 10, 20Hz	1.25, 2.5, 5, 10, 20Hz	1.25, 2.5, 5, 10, 20Hz
Power Aperture	User calibrated	User calibrated	User calibrated
Power Aperture OD	Metallized Quartz (200mW)	Metallized Quartz (200mW)	Metallized Quartz (200mW)
Laser Type	CW or Pulsed[2]	CW or Pulsed[2]	CW or Pulsed[2]
Operating Range	See Operating Space Chart in Appendix C of User's Manual	See Operating Space Chart in Appendix C of User's Manual	See Operating Space Chart in Appendix C of User's Manual
Damage Threshold	see Operating Space Chart in Appendix C of User's Manual	See Operating Space Chart in Appendix C of User's Manual	See Operating Space Chart in Appendix C of User's Manual
Rotation Mount	Standard – see drawing in Appendix B of User's Manual	Standard – see drawing in Appendix B of User's Manual	Standard – see drawing in Appendix B of User's Manual
Scanhead Dimension	See Mechanical Drawing in Appendix of User's Manual	See Mechanical Drawing in Appendix B of User's Manual	See Mechanical Drawing in Appendix B of User's Manual

1. Assumes Gaussian (TEM00) Beam
2. Pulsed Operation Limited to Beam Diameter >≥100µm and pulse repetition rate ≥5kHz.

NanoScan Scanhead Model	Ge/3.5/1.8µm	Ge/9/5µm	Ge/9/25µm
Wavelength	700nm - 1800nm	700nm - 1800nm	700nm - 1800nm
Detector	Germanium	Germanium	Germanium
Entrance Aperture	3.5mm	9mm	9mm
Slit Size	1.8µm	5µm	25µm
1/e² Beam Diameter Range[1]	4µm – ~2.3mm	20µm – ~6mm	100µm – ~6mm
Spatial Sampling Resolution	5.3nm – 18.3µm	5.3nm – 18.3µm	5.3nm – 18.3µm
Profile Digitization	16 bit	16 bit	16 bit
Scan Frequency	1.25, 2.5, 5, 10, 20Hz	1.25, 2.5, 5, 10, 20Hz	1.25, 2.5, 5, 10, 20Hz
Power Aperture	User calibrated	User calibrated	User calibrated
Power Aperture OD	Metallized Quartz (200mW)	Metallized Quartz (200mW)	Metallized Quartz (200mW)
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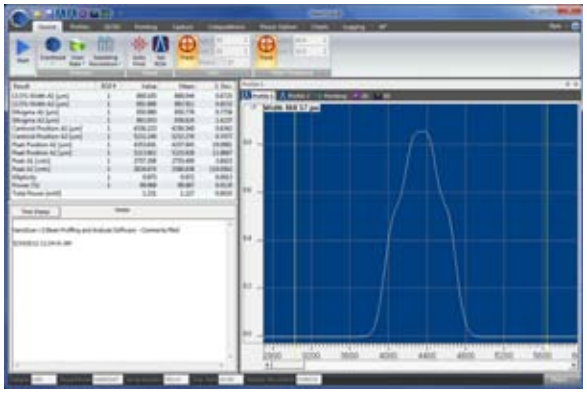
The Most Versatile and Flexible Beam Profiling System Available

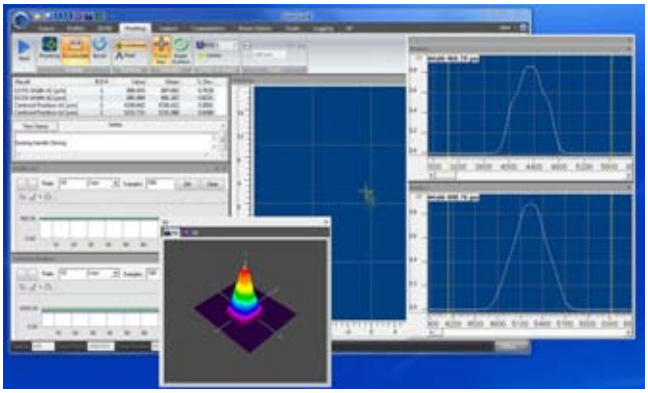
Photon's NanoScan scanning slit profilers provide major performance enhancements while maintaining the ease-of-use and flexibility that customers have come to expect with its predecessor, the world-renowned BeamScan. NanoScan 2 scanheads are available to measure CW and pulsed beams across the entire spectral range from UV to infrared.

See Your Beam As Never Before

The Graphical User Interface (GUI) of NanoScan is new. Dockable and floatable windows plus concealable ribbon tool bars empower the NanoScan user to make the most of a small laptop display or a large, multi-monitor desktop PC.



Simple docked view



Both docked and undocked windows

Measured Beam Results

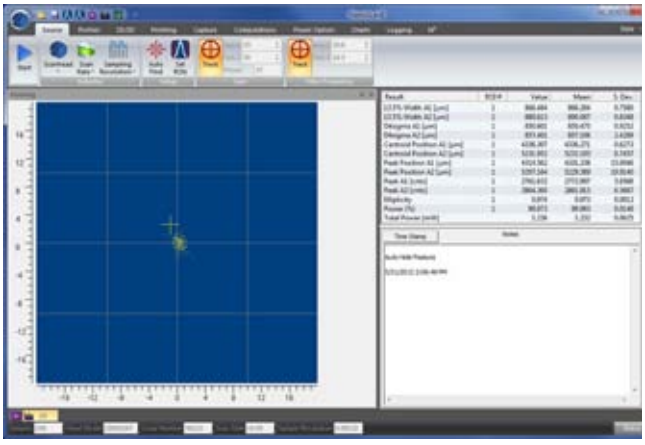
From 1989 through 1996, John Fleischer, past President of Photon Inc., chaired the working laser beam width ISO/DIN committee that resulted in the ISO/DIN 11146 standard. The final approved standard, available in 13 languages. The standard governs profile measurements and analysis using scanning apertures, variable apertures, area sensors and detector arrays. NanoScan measures spatial beam irradiance profiles using scanning slit techniques. The standard NanoScan uses the moving-slit method, approved by International Standard ISO/DIN 11146..

Results measured include:

- Beam Width at various clip levels
- Centroid Position
- Peak Position
- Ellipticity
- 1D Gaussian Fit
- Beam Divergence
- Beam Separation
- Pointing Stability
- ROI Power (optional)
- Total Power (optional)
- Peak (in digitizer counts)
- Pulsed Laser Repetition Rate

Result	ROI #	Value	Mean	S. Dev.
13.5% Width A1 [µm]	1	863.328	864.612	0.7082
13.5% Width A2 [µm]	1	876.317	875.622	0.9432
D4sigma A1 [µm]	1	849.062	849.700	1.5084
D4sigma A2 [µm]	1	842.054	840.924	2.3751
Centroid Position A1 [µm]	1	1.111	-0.133	0.5622
Centroid Position A2 [µm]	1	-1.730	0.275	1.2221
Peak Position A1 [µm]	1	-11.521	-19.890	5.6014
Peak Position A2 [µm]	1	4.156	8.732	6.9860
Peak A1 [cnts]	1	2812.438	2810.688	4.0486
Peak A2 [cnts]	1	2687.898	2678.320	5.5879
Ellipticity	1	0.806	0.807	0.0023
Power [%]	1	99.994	99.979	0.0273
Total Power [mW]		1.202	1.203	0.0002

Example of the many measurements that can be made and the precision you can expect



Knowing pointing stability is a critical factor in laser performance

Optional Automation Interface

The Pro model scanheads implement an Automation Server that can be used by an Automation Client written in Visual Basic for Applications (VBA), C/C++ or by an application with support for ActiveX Automation, such as Microsoft Excel, Microsoft Word or National Instruments' LabVIEW.

NanoScan Acquisition and Analysis Software

*Feature		NanoScan Standard	NanoScan Professional (all features in Standard plus)
Controls			
Source	ScanHead Select, Gain, Filter, Sampling Resolution, AutoFind, Rotation Frequency, Record Mode	●	
Capture	Averaging, Rotation, Magnification, CW or Pulse Modes, Divergence, Gaussian Fit, Reference Position, Recompute	●	
Regions of Interest (ROI)	Single or Multiple, Automatic or Manual, Colors	●	
Profiles	Vertical Scale (1´, 10´, 100´), Logarithmic Scale, Z & PAN (Automatic or Manual)	●	
Computation: ISO 13694, ISO 11146	D_{slit}, (13.5%, 50% 2 User Selectable Clip Levels), $D_{4\sigma}$, Width ratios, Centroid Position, Peak Position, Centroid Separation, Peak Separation, Irradiance, Gaussian Fit, Ellipticity, Divergence, Total Power, Pulse Frequency, % power	●	
	Continuous, Rolling, Finite	●	
Pointing	Centroid or Peak, Accumulate Mode, Beam Indicator, Graph Center, Colors	●	
2D/3D	2D or 3D Mode, Linear or Logarithmic Scale, Resolution, Fill Contours, Solid Surface, or Wireframe, Clip Level Colors	●	
Charts	Chart Select, Parameter Select, Aperture Select, Update Rate, Start and Clear	●	
Logging	File Path/Name, Delimiter, Update Rate	●	
M^2	Rail Setup: Com Port and Length, Connect/Disconnect, Rail Control	●	
Views			
Profiles	Displays Beam Profiles for each axis, with optional Gaussian Overlays	●	
Results	Displays Values and Statistics for Selected results	●	
Pointing	Displays the XY position of the Centroid or Peak for each ROI , with optional overlays and Accumulate Mode	●	
Charts	Displays Time Charts for User-selected results	●	
2D/3D	Displays pseudo 2D/3D Beam Profile	●	
M^2 Wizard	An interactive procedure for measuring M2 by the Rayleigh Method	●	
File Saving			
NanoScan Data Files		●	
Text Files		●	
Data Logging			
Log to File		●	
Reports			
NanoScan Report		●	
Automation Interface			
ActiveX Automation Server			●
Minimum System Requirements			
PC computer running windows 7 (32/64) Laptop or Desktop[1]			
A dual core processor CPU, 2GHz or better			
2GB of RAM[2]			
1-USB 2.0 port available			
At least 250MB of free HDD space			
1400 x 900 display resolution or better			
Graphics card w/hardware accelerator			
DVD-ROM drive			
Microsoft compatible pointing devices(e.g., mouse, trackball, etc)			

*Download the NanoScan Acquisition and Analysis Software Manual for a complete description of all Software Features

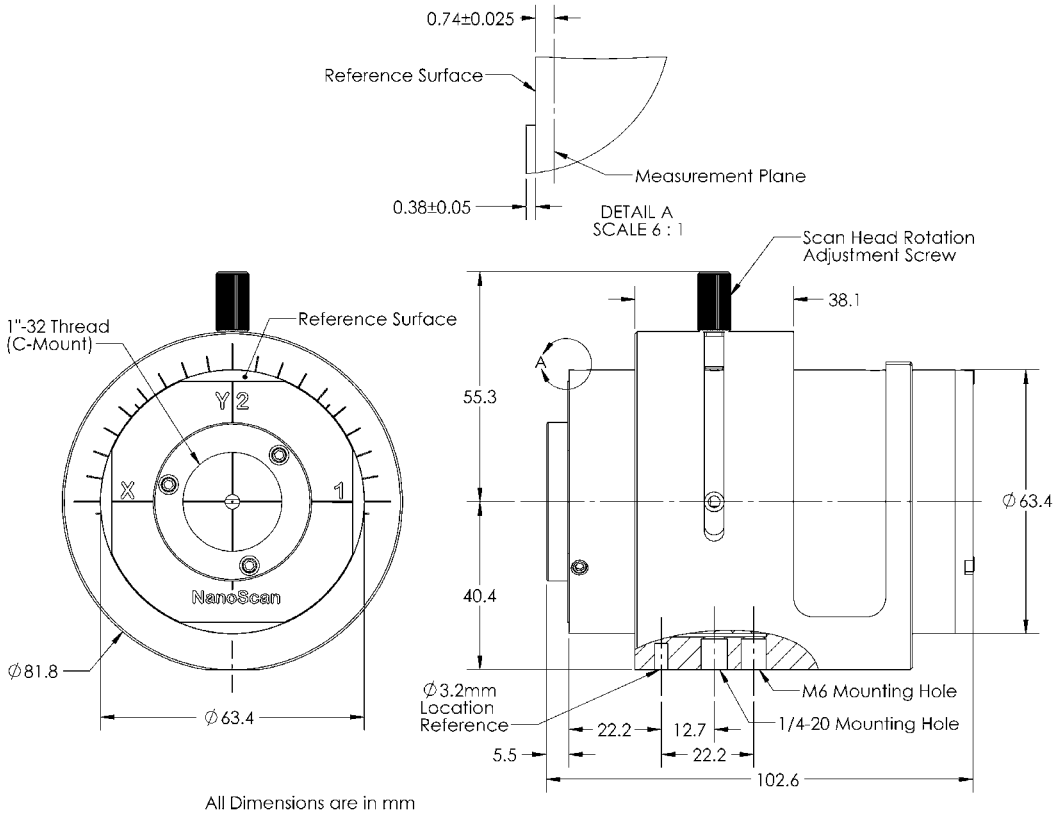
1. A business/professional version of windows is recommended. The NanoScan v2 software has not been tested with home versions of Windows. Both 64-bit and 32-bit versions of Windows 7 are supported. NanoScan v2 is no longer tested on Windows XP 32-bit operating systems.
2. The computer memory (RAM) will affect the performance of the software in the Data Recorder.

Specifications

Model	YAG Focal Spot Analyzer
Bus interface	USB 2.0
Signal digitization	16bit
Maximum digitization clock	20MHz
Maximum update rate	20Hz
Data transfer	Bulk Transfer Mode
On-board memory	64MB mDDR SDRAM
Weight	434g (15.3 ounces)
Operating temperature	0…50°C
Humidity	90%, non-condensing
Scanhead Dimensions	3.85"(9.78cm) L X 2.5"(6.35cm) Ø
Power	USB 2.0 Bus Powered
CPU Clock	300MHz
Memory Clock	264MHz
Scanning Motor	Brushed DC, 4W max

Mechanical Dimensions

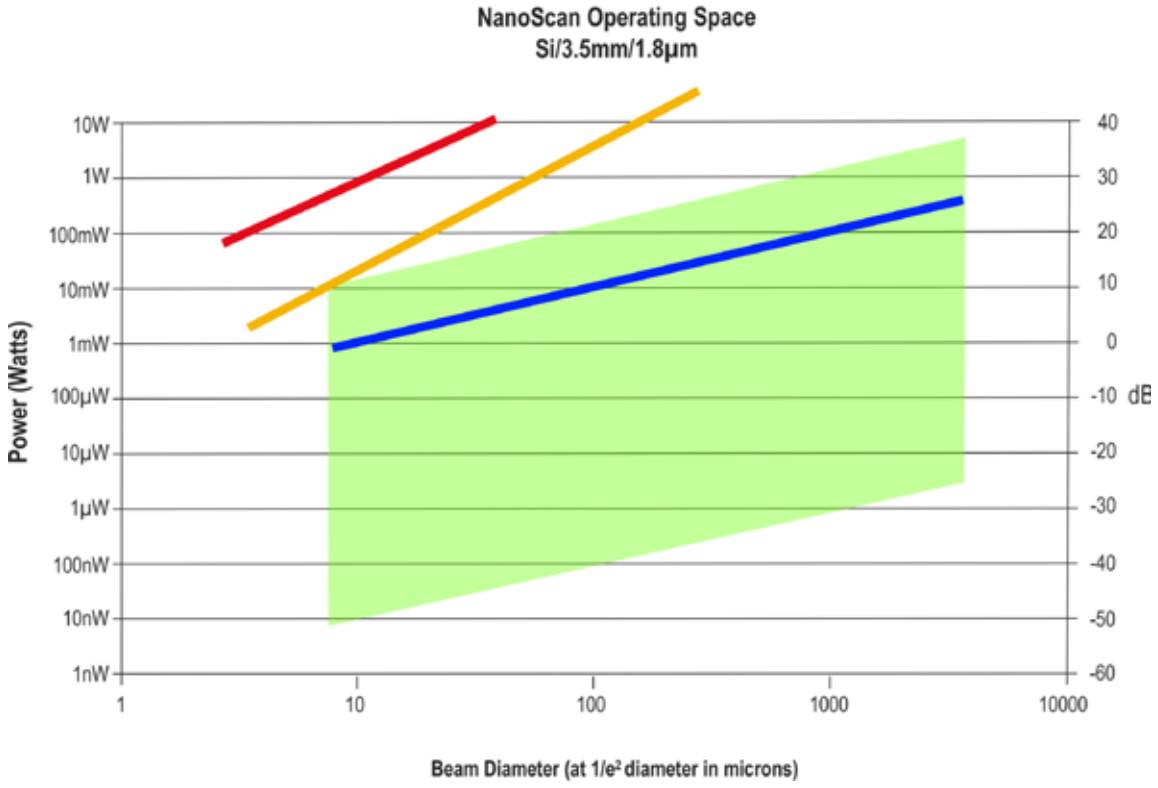
NanoScan2 Standard Scanhead: NS2-Si and NS2-Ge



All Dimensions are in mm

Typical NanoScan Operating Space Charts

Operating Range is at Peak Sensitivity of Detector.
Operating Space is NOT absolute.
THESE CHARTS TO BE USED AS A GUIDE ONLY.



Silicon Detector

Silicon Detector: Responsivity varies with wavelength. Detects between 190-950nm. Peak responsivity is 0.4 amps/watt at 850nm. Detector to detector responsivity variation can be as great as ±20%.

Power: Power in the measured laser beam. Assumes a round beam diameter. An elliptic beam can be approximated by using the maximum width dimension and assuming all the energy is in a beam of this diameter. For extremely elliptic beams (ratio >4:1)/ contact the factory.

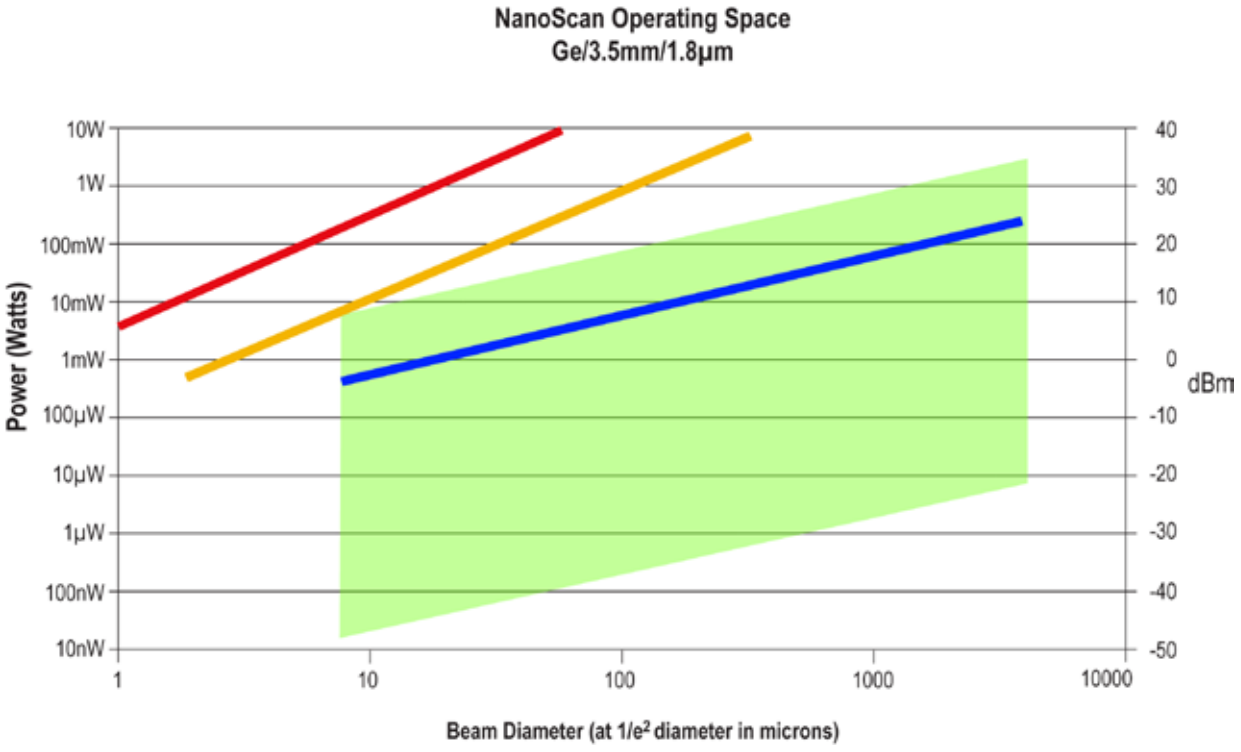
Pulsed Operation (———): Upper limit of the operating space for pulsed laser measurements.

Black Coating Removed (———): Slits are blackened to reduce back reflections; blackening begins to vaporize near this line. Slits in pyrodetectors are not blackened.

Slit Damage (———): Power density (watts/cm^2) where one can begin to cut the slits. Refer to Photon's Damage Threshold with High Power Laser Measurements document.

Left Boundary: Smallest beam size limited to 4-5 times the slit width. Some models have another limit due to electrical bandwidth.

Right Boundary: Instrument entrance aperture. The largest beam width (1/e^2) will be the aperture divided by 1.2-1.4.



Germanium Detector

Responsivity: Detector conversion constant, incident photons to a current.

Detector: Responsivity varies with wavelength. Detects between 700-1800nm. Peak responsivity is 0.7 amps/watt at 1550nm. Detector to detector responsivity variation can be as great as ±20%.

Power: Power in the measured laser beam. Assumes a round beam diameter. An elliptic beam can be approximated by using the maximum width dimension and assuming all the energy is in a beam of this diameter. For extremely elliptic beams (ratio >4:1) contact the factory.

Beam Diameter: Circular laser spot being measured by a narrow slit. Clip level method.

Pulsed Operation (———): Upper limit of the operating space for pulsed laser measurements.

Black Coating Removed (———): Slits are blackened to reduce back reflections; blackening begins to vaporize near this line. Slits in pyro detectors are not blackened.

Slit Damage (———): Power density (watts/cm^2) where one can begin to cut the slits. Refer to Photon's Aperture Damage due to High Incident Power document.

Left Boundary: Smallest beam size limited to 4-5 times the slit width. Some models have another limit due to electrical bandwidth.

Right Boundary: Instrument entrance aperture. The largest beam width (1/e^2) will be the aperture divided by 1.2-1.4.

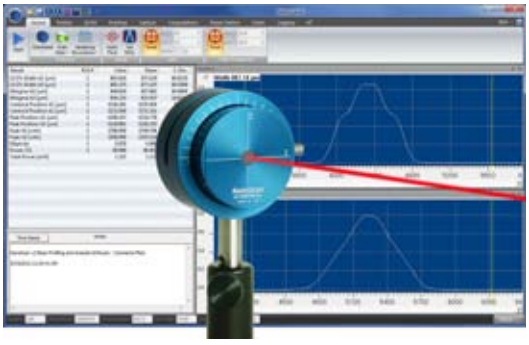
NanoScan Options and Accessories

Item	Description	P/N
NS2-SI/3.5/1.8-STD	NanoScan2 Silicon Detector 3.5mm aperture 1.8micron slits. High-resolution head featuring Silicon detector, 63.5mm diameter head with rotation mount, 3.5mm entrance aperture, and matched pair of 1.8micron wide slits. Use from 190nm to wavelengths <1micron. Not for 1.06micron wavelength.	PH00421
NS2-Si/9/5-STD	NanoScan2 Si Detector 9mm aperture 5micron slits. High-resolution head featuring Si detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5 micron wide slits. Use from 190nm to wavelengths <1micron. Not for 1.06micron wavelength.	PH00422
NS2-Si/9/25-STD	NanoScan2 Si Detector 9mm aperture 25micron slits. High-resolution head featuring Si detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 25 micron wide slits. Use from 190nm to wavelengths <1micron. Not for 1.06micron wavelength.	PH00423
NS2-Ge/3.5/1.8-STD	NanoScan2 Ge Detector 3.5mm aperture 1.8micron slits. High-resolution head featuring Germanium detector, 63.5mm diameter head with rotation mount, 3.5mm entrance aperture, and matched pair of 1.8 micron wide slits. Use from 700nm to 1.8micron wavelength.	PH00424
NS2-Ge/9/5-STD	NanoScan2 Ge Detector 9mm Aperture 5.0micron slits. High-resolution head featuring Germanium detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5 micron wide slits. Use from 700nm to 1.8micron wavelength.	PH00425
NS2-Ge/9/25-STD	NanoScan2 Ge Detector 9mm Aperture 25 micron slits. High-resolution head featuring Germanium detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 25 micron wide slits. Use from 700nm to 1.8micron wavelength.	PH00426
NS2-Si/3.5/1.8-PRO	Software includes ActiveX automation feature.	PH00429
NS2-Si/9/5-PRO	NanoScan2 Silicon Detector 3.5mm aperture 1.8micron slits. High-resolution head featuring Silicon detector, 63.5mm diameter head with rotation mount, 3.5mm entrance aperture, and matched pair of 1.8 micron wide slits. Use from 190nm to wavelengths <1micron. Not for 1.06micron wavelength.	PH00430
NS2-Si/9/25-PRO	Software includes ActiveX automation feature.	PH00431
NS2-Ge/3.5/1.8-PRO	NanoScan2 Si Detector 9mm aperture 5micron slits. High-resolution head featuring Si detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5 micron wide slits. Use from 190nm to wavelengths <1micron. Not for 1.06micron wavelength.	PH00432
NS2-Ge/9/5-PRO	Software includes ActiveX automation feature.	PH00433
NS2-Ge/9/25-PRO	NanoScan2 Si Detector 9mm aperture 25micron slits. High-resolution head featuring Si detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 25 micron wide slits. Use from 190nm to wavelengths <1micron. Not for 1.06micron wavelength.	PH00434

3.3.1 NanoScan™

Scanning Slit Beam Profiler For High Accuracy Dimensional Measurement

NanoScan is a PC-based instrument for the measurement and analysis of optical beam spatial profiles in accordance with ISO standards. Beam profiles are measured using the International Standard ISO 11146. Scanheads that are fitted with an optional power feature can measure power in accordance with ISO 13694.



The system comprises a scanhead for sensing the laser beam, a USB 2.0 controller, and NanoScan software. An optional automation feature includes an ActiveX automation server.

NanoScan uses moving slits, one of the ISO Standard scanning aperture techniques. Measurement is possible for beam sizes from microns to centimeters at beam powers from microwatts to over kilowatts, often without attenuation. Detector options (silicon, germanium, and pyroelectric technologies) allow measurement at wavelengths from the ultraviolet to the far infrared. It can simultaneously measure multiple beams and offers an optional power meter for scanheads with silicon and germanium detectors.

Profiles are acquired with 12-bit digitization, and analyzed for real-time updates up to the maximum scanhead scan rate of 20Hz. With NanoScan, beam profile measurement is extremely easy: simply position the scanhead in the beam path and within seconds the system does the rest.

Benefits

- All NanoScan systems are calibrated to a NIST traceable source to ensure the ultimate in accuracy.
- The software finds a beam in less than 0.3 seconds and displays real-time updates up to 20Hz.
- The Z-axis datum plane of the NanoScan is known to ±25µm making the locating of beam waist position simple and accurate.
- Along with the ability to measure pulsed beam diameters, the NanoScan accurately measures and reports the pulse frequency of the laser, ensuring that the pulsed beam measurements are stable and accurate.
- The sampling interval for beam measurements is adjustable to as little as 5.7nm, providing the extreme accuracy required to measure very small beams.
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- Software has a built-in M^2 Wizard to assist in making manual propagation ratio measurements.
- Time charts allow any beam result to be charted over time.
- Results logging to text files.
- Optional ActiveX Automation commands with samples of automation programs for Excel VBA, LabView and Visual Basic.net.
- Optional power meter with silicon and germanium scanhead.

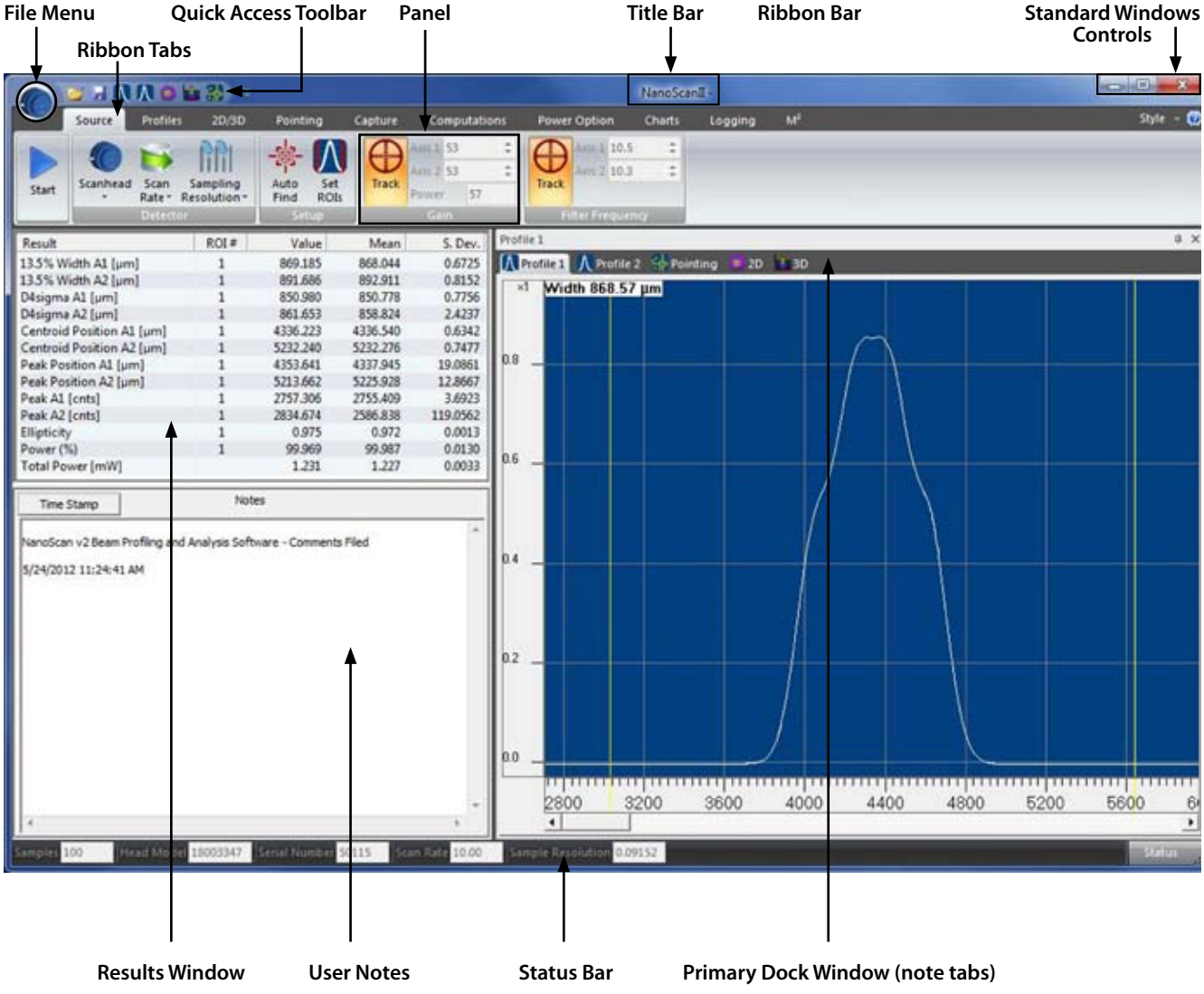
NanoScan Option NSEC: Side exit cable

Measure Your Beam as Never Before

The system has a USB 2.0 interface and operates with the latest Microsoft operating systems 64/32-bit Windows 7, and provides deep, 12-bit digitization of the signal for enhanced dynamic range up to 35dB optical power. The digital controller improves the accuracy and stability of the beam profile measurement by orders of magnitude. It is now possible to measure beam size and beam pointing with a 3-sigma precision of 1µm or better. The software controllable scan speed and a "peak-connect" algorithm allow the measurement of pulsed and pulse width modulated lasers with frequencies of a few kHz and higher with any detector.*

*The minimum frequency is a function of the beam size and the scan speed. This is a simple arithmetic relationship; there must be a sufficient number of pulses during the time that the slits sweep through the beam to generate a meaningful profile. Please refer to Photon's Application Note, Measuring Pulsed Beams with a Slit-Based Profiler.

NanoScan Main Display Screen



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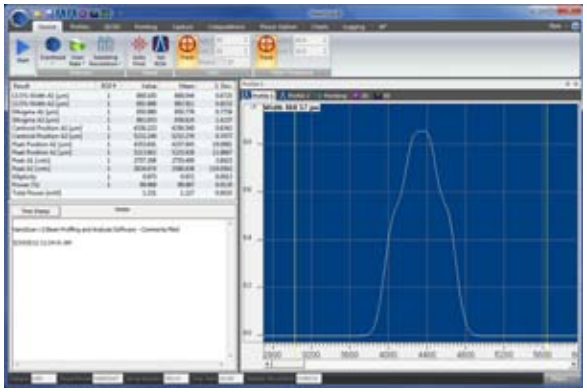
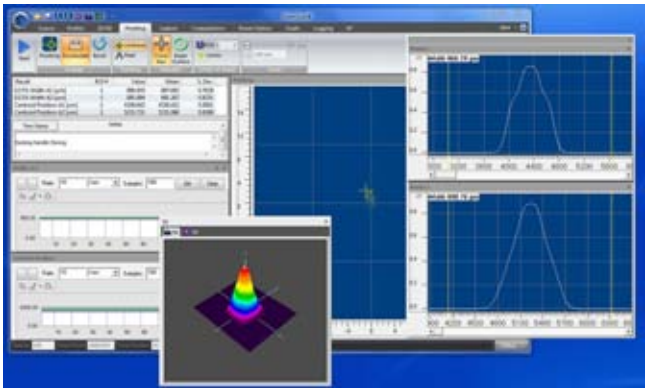


Simple docked view



Both docked and undocked windows

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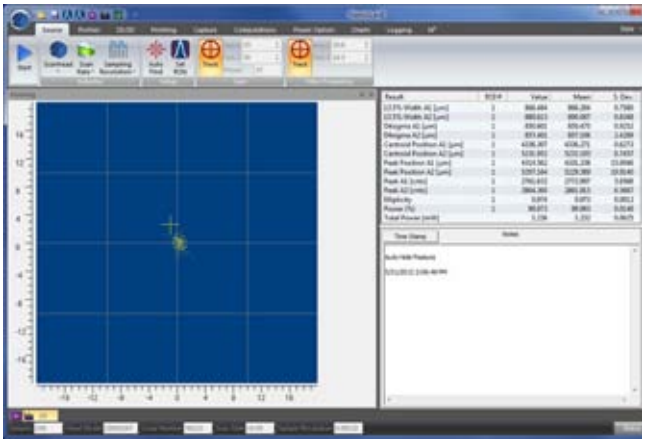
D4sigma A2 [µm]	1	842.054	840.924	2.3751
Centroid Position A1 [µm]	1	1.111	-0.133	0.5622
Centroid Position A2 [µm]	1	-1.730	0.275	1.2221
Peak Position A1 [µm]	1	-11.521	-19.890	5.6014
Peak Position A2 [µm]	1	4.156	8.732	6.9860
Peak A1 [cnts]	1	2812.438	2810.688	4.0486
Peak A2 [cnts]	1	2687.898	2678.320	5.5879
Ellipticity	1	0.806	0.807	0.0023
Power [%]	1	99.994	99.979	0.0273
Total Power [mW]		1.202	1.203	0.0002

Example of the many measurements that can be made and the precision you can expect



Knowing pointing stability is a critical factor in laser performance

Multiple Beam Analysis Software

The NanoScan software is an integrated package for Microsoft Windows operating systems, it can measure from one to 16 beams in the NanoScan aperture, all with sub-micron precision. The optimal-pro software includes ActiveX automation for users who want to integrate the NanoScan into OEM systems or write their own user interface screens.

M^2 Wizard

M-squared (M^2) software Wizard is an interactive program for determining the "times diffraction limit" factor M^2 by the Rayleigh Method. The M^2 Wizard prompts and guides the user through a series of manual measurements and data entries required for calculating M^2.

The Optional Rayleigh Range Translation Test Fixture (RAL-FXT) provides convenient translation of a NanoScan scanhead assembly and a digital readout of its relative position along the Z-axis. Used with a user-provided focusing lens and the M^2 Wizard in the NanoScan Analysis Software, this fixture offers a quick and easy method to determine the times-diffraction propagation factor (M^2) of a laser.

The optional Translation Test Fixture makes manual M2 measurements accurate and repeatable

The RAL-FXT features a base plate, sliding carriage and digital micrometer. The base plate (5.4×10.2×0.38in.) provides a series of ¼-20 threaded mounting holes at 2in. centers to facilitate convenient fixturing of the assembly with respect to the focusing lens. The sliding carriage accommodates the combination of the 0.125-in. dowel pin and the ¼-20 mounting hole found on any Photon scan head's rotation mount, and enables smooth movement of the scan head assembly over a 6-in. range of travel. A Mitutoyo micrometer with a handy re-zeroing feature and accompanying slide provides precise determination of the scan head location and/or travel distance with a resolution of tens of microns.

For automated and automatic M^2 measurements the NanoModeScan option is required.

Pulsed Laser Beam Profiling

In addition to profiling CW laser beams, NanoScan can also profile pulsed laser beams with repetition rate in the 1kHz range and above. To enable the measurement of these pulsed lasers, the NanoScan profiler incorporates a "peak connect" algorithm and software-controlled variable scan speed on all scanheads. The accuracy of the measurement generally depends on the laser beam spot size and the pulse-to-pulse repeatability of the laser. The NanoScan is ideal for measuring Q-switched lasers and lasers operating with pulse width modulation power (PWM) control. In the past few years, lasers with pico- and femtosecond pulse durations have begun to be used in many applications. Although these lasers add some additional complication to the measurement techniques, the NanoScan can also measure this class of laser.

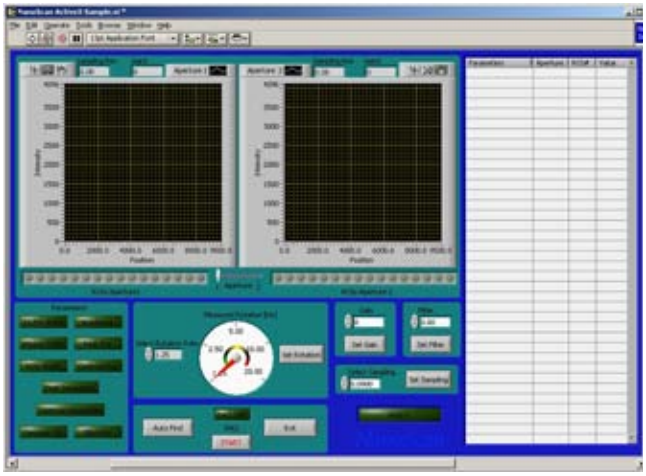
Optional Power Meter

The silicon and germanium NanoScan systems offer the 200mW power meter as an option. The power meter can be calibrated against the user's ISO- or NIST- traceable power meter. The 200mW power meter has a quartz attenuator window that provides a uniform response across a broad wavelength range with a 1.5% accuracy when used in the same geometry as calibrated.

The power meter screen in the software shows both the total power and the individual power in each of the beams being measured. The power meter option is not available with pyroelectric detectors.

Optional Automation Interface

The Pro model scanheads implement an Automation Server that can be used by an Automation Client written in Visual Basic for Applications (VBA), C/C++ or by an application with support for ActiveX Automation, such as Microsoft Excel, Microsoft Word or National Instruments' LabVIEW.



Full featured application examples are included to help your learning curve when embedding NanoScan - PRO into an automation application

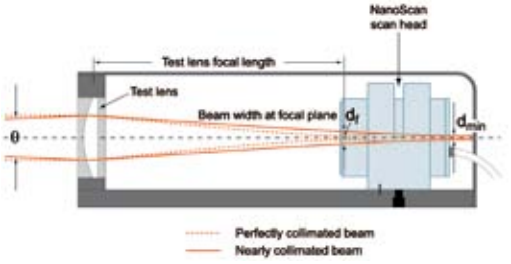
Optional Collimation Fixture

A single beam size measurement using a Collimation Fixture is all that is required to determine laser beam collimation or divergence angle. Real-time optical alignment can then be performed to determine best collimation. No special training is needed to perform these simple measurements. Unlike with most measurement shortcuts, high-precision collimation measurements can be performed with exceedingly high resolution, higher than alternative techniques. All that is required for these accurate measurements of collimation is a test lens and a NanoScan. The laser beam profiler is positioned such that it measures beam size at the geometric focus of the lens. From lens theory, the angle of collimation is determined by the equation: $q = D_f / f$, where q is the angle of collimation, D_f is the beam size measured at the focal length, and f is the focal length of the lens. Once the beam size is measured at the focal length of the lens, simply dividing this measured beam size by the divergence angle determines the laser beam collimation angle. The beam profiler remains fixed, and active alignment is easily performed in real time. This level of simplicity, speed, and functionality is simply not possible with techniques involving multiple beam profile positions.

Divergence/Collimation test fixtures based on a high quality test lens to focus your collimated or diverging beam.

Fixtures require a complete NanoScan System.

COL-FXT 250	Nominal 250mm focal length lens. Includes an enclosure to block stray light
COL-FXT 250 TEL	Nominal 250mm focal length lens. For wavelengths of use at 1310 or 1550nm with lens repositioning. Includes an enclosure to block stray light
COL-FXT 500 MIR	For wavelengths of use at 3–5µm.
COL-FXT C02	Zinc selenide (ZnSe) lens with a focal length of 190.5mm. For wavelength of use at 10.6m. Includes an enclosure that holds an adjustable entrance iris. Requires a Pyro NanoScan System.



NanoScan Configurations

Detector Type	Power Range	Wavelength	Aperture	Slits	Scanhead Size
Silicon	~100nW-~100mW	190nm-950nm	25mm	25µm	100mm
Germanium	~1µW-~100mW	700nm-1800nm	12mm	25µm	100mm
Pyroelectric	100mW-100W	200nm- >2.0µm	9mm	5µm	63mm
				25mm	
			20mm	25µm	100mm

The power that can be handled by the NanoScan is dependent on the wavelength of the light to be measured. The wavelength of light determines both its reflectivity from the slit surfaces and the energetic nature of the interactions with materials. As a rule of thumb, there are three basic wavelength regimes that govern how much power the scanhead can handle:

- 3µm to FIR (>20µm) –100W maximum pyroelectric detector
- 700nm to 3µm—25W maximum pyroelectric detector; 1W germanium detector
- 190nm to 700nm—3W maximum pyroelectric detector; 1W silicon detector

Power levels above these for any of these wavelengths can be considered "High Power." See the High Power NanoScan section for appropriate products. **Consult the damage thresholds charts found in the manual before placing an order or exposing any NanoScan slit profiler to a laser beam.**

NanoScan Acquisition and Analysis Software

*Feature		NanoScan Standard	NanoScan Professional (all features in Standard plus)
Controls			
Source	ScanHead Select, Gain, Filter, Sampling Resolution, AutoFind, Rotation Frequency, Record Mode	●	
Capture	Averaging, Rotation, Magnification, CW or Pulse Modes, Divergence, Gaussian Fit, Reference Position, Recompute	●	
Regions of Interest (ROI)	Single or Multiple, Automatic or Manual, Colors	●	
Profiles	Vertical Scale (1´, 10´, 100´), Logarithmic Scale, Z & PAN (Automatic or Manual)	●	
Computation: ISO 13694, ISO 11146	D_{slit}, (13.5%, 50% 2 User Selectable Clip Levels), $D_{4\sigma}$, Width ratios, Centroid Position, Peak Position, Centroid Separation, Peak Separation, Irradiance, Gaussian Fit, Ellipticity, Divergence, Total Power, Pulse Frequency, % power	●	
	Continuous, Rolling, Finite	●	
Pointing	Centroid or Peak, Accumulate Mode, Beam Indicator, Graph Center, Colors	●	
2D/3D	2D or 3D Mode, Linear or Logarithmic Scale, Resolution, Fill Contours, Solid Surface, or Wireframe, Clip Level Colors	●	
Charts	Chart Select, Parameter Select, Aperture Select, Update Rate, Start and Clear	●	
Logging	File Path/Name, Delimiter, Update Rate	●	
M^2	Rail Setup: Com Port and Length, Connect/Disconnect, Rail Control	●	
Views			
Profiles	Displays Beam Profiles for each axis, with optional Gaussian Overlays	●	
Results	Displays Values and Statistics for Selected results	●	
Pointing	Displays the XY position of the Centroid or Peak for each ROI , with optional overlays and Accumulate Mode	●	
Charts	Displays Time Charts for User-selected results	●	
2D/3D	Displays pseudo 2D/3D Beam Profile	●	
M^2 Wizard	An interactive procedure for measuring M2 by the Rayleigh Method	●	
File Saving			
NanoScan Data Files		●	
Text Files		●	
Data Logging			
Log to File		●	
Reports			
NanoScan Report		●	
Automation Interface			
ActiveX Automation Server			●
Minimum System Requirements			
PC computer running windows7 (32/64) Laptop or Desktop			
Core CPU 2GHz or better			
3GB of RAM or better			
1 USB 2.0 port			
At least 250MB free HDD space			
1440x900 Display Resolution or greater			
Add-in PCI/PCI-Express graphics card w/hardware acceleration			
DVD-ROM drive			

*Download the NanoScan Acquisition and Analysis Software Manual for a complete description of all Software Features

Ordering Information - NanoScan Systems

Both -STD & -PRO NanoScan Systems Include: NanoScan v2 Integrated Software package for use with NanoScan scanheads under Microsoft Windows operating systems.

ActiveX automation is provided in -PRO models.

Certificate of Calibration. Beam width is traceable to National Institute of Standards and Technology (NIST) to better than ±2% (NanoScan Pyroelectric detectors calibration to better than ±3%).

Item	Description	P/N
USB NS-Si/25/25-STD	NanoScan Si Detector 25mm aperture 25micron slits. High-resolution head featuring Si detector, 100mm diameter head with rotation mount, 25mm entrance aperture, and matched pair of 25.0micron wide slits. Use from 190nm to wavelengths <1micron. Not for 1.06micron wavelength. USB	PH00390
USB NS-Si/25/25-PRO	Software includes automation feature. NanoScan Si Detector 25mm aperture 25micron slits. High-resolution head featuring Si detector, 100mm diameter head with rotation mount, 25mm entrance aperture, and matched pair of 25.0micron wide slits. Use from 190nm to wavelengths <1micron. Not for 1.06micron wavelength. USB	PH00019
USB NS-Ge/12/25-STD	NanoScan Ge Detector 12.5mm Aperture 25micron slits. High-resolution head featuring Germanium detector, 100mm diameter head with rotation mount, 12.5mm entrance aperture, and matched pair of 25micron wide slits. USB	PH00395
USB NS-Ge/12/25-PRO	Software includes automation feature. NanoScan Ge Detector 12.5mm Aperture 25micron slits. High-resolution head featuring Germanium detector, 100mm diameter head with rotation mount, 12.5mm entrance aperture, and matched pair of 25micron wide slits. USB	PH00024
USB NS-PYRO/9/5-STD	NanoScan Pyroelectric Detector 9mm aperture 5micron slits. High-resolution head featuring pyroelectric detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5µm wide slits. Use for wavelengths from 190nm to >20µm. This model does not include a cooling fan. USB	PH00396
USB NS-PYRO/9/5-PRO	Software includes automation feature. NanoScan Pyroelectric Detector 9mm aperture 5micron slits. High-resolution head featuring pyroelectric detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5µm wide slits. Use for wavelengths from 190nm to >20µm. This model does not include a cooling fan. USB	PH00025
USB NS-PYRO/9/25-STD	NanoScan Pyroelectric Detector 9mm aperture 25micron slits. High-resolution head featuring pyroelectric detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 25µm wide slits. Use for wavelengths from 190nm to >20µm. This model does not include a cooling fan.	PH00400
USB NS-PYRO/9/25-PRO	Software includes automation feature. NanoScan Pyroelectric Detector 9mm aperture 25micron slits. High-resolution head featuring pyroelectric detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 25µm wide slits. Use for wavelengths from 190nm to >20µm. This model does not include a cooling fan.	PH00228
USB NS-PYRO/20/25-STD	NanoScan Large Area Pyroelectric Detector 20mm aperture 25micron slits. High-resolution head featuring pyroelectric detector, 100mm diameter head with rotation mount, 20mm entrance aperture, and matched pair of 25micron wide slits. Use for wavelengths from 190nm to >20micron. This model does not include a cooling fan. USB	PH00397
USB NS-PYRO/20/25-PRO	Software includes automation feature. NanoScan Large Area Pyroelectric Detector 20mm aperture 25micron slits. High-resolution head featuring pyroelectric detector, 100mm diameter head with rotation mount, 20mm entrance aperture, and matched pair of 25micron wide slits. Use for wavelengths from 190nm to >20micron. This model does not include a cooling fan. USB	PH00026
NS-USB	NanoScan USB Controller /NS USB	PH00030
NH NS-Si/25/25-STD	Head only NanoScan-Si 25mm aperture 25µm slits	PH00406
NH NS-Si/25/25-PRO	Head only NanoScan-Si 25mm aperture 25µm slits	PH00035
NH NS-Ge/12/25-STD	Head only NanoScan-Ge 12mm aperture 25µm slits	PH00411
NH NS-Ge/12/25-PRO	Head only NanoScan-Ge 12mm aperture 25µm slits	PH00040
NH-PYRO/9/5-STD	Head only NanoScan-Pyro 9mm aperture 5µm slits	PH00412
NH-PYRO/9/5-PRO	Head only NanoScan-Pyro 9mm aperture 5µm slits	PH00041
NH-PYRO/9/25-STD	Head only NanoScan-Pyro 9mm aperture 25µm slits	PH00416
NH-PYRO/9/25-PRO	Head only NanoScan-Pyro 9mm aperture 25µm slits	PH00243
NH-PYRO/20/25-STD	Head only NanoScan-Pyro 20mm aperture 25µm slits	PH00413
NH-PYRO/20/25-PRO	Head only NanoScan-Pyro 20mm aperture 25µm slits	PH00042
Software Upgrades		
NSv2 STD to NSv2 PRO Upgrade	Upgrade NanoScan v2 Standard version software to the PRO version. This upgrade opens the NanoScan automation feature for those users wanting to integrate or develop their own interface using Visual Basic for Applications to embed into such applications as LabView. Return scanhead to factory.	PH00417
NSv1 to NSv2 STD Upgrade	For those NanoScan users with pre v2 software (approx. before July 2012) they can upgrade their hardware to v2 STD capability and can run the new software. Automation capability is not available in v2 STD. Once upgraded the legacy software will run but the automation feature will be disabled in v2	PH00418
NSv1 to NSv2 PRO Upgrade	For those NanoScan users with pre v2 software (approx. before July 2012) they can upgrade their hardware to v2 PRO capability and can run the new software. Automation capability is included in v2 PRO. Once upgraded the legacy software will run including the automation capability in v2	PH00419
Legacy Software	Purchase the legacy V1.47 NanoScan software with licence and operations manual to –PRO scanheads to use the older software. (return scanhead to factory)	PH00420

NanoScan Options and Accessories

Item	Description	P/N
P200 Power Option	200mW (maximum power level) relative power meter option for Silicon or Germanium detector NanoScans. The /P200 provides better than 1.5% accuracy when calibrated against user's NIST traceable power meter and used in similar input geometry as calibrated.. Not applicable to Pyro-electric detector scan heads NOTE: P200 must be specified at time of purchase (Can be returned for upgrading)	PH00046
NSEC	Side exit cable option for NanoScan	PH00252
Cable-x	Custom NanoScan cable-length x	PH00049
NS-YE	Extension NanoScan cable 3m	PH00050
C-Mnt	C-Mount attachment for NS	PH00051
COL-FXT 250	250 mm FL collimation fixture	PH00070
PFSA	UV-Grade fused silica right angle prism front surface attenuator in C-mount housing. Provides 4% front surface reflection	PH00052
DPFSA	Dual prism front surface attenuator comprising two UV-Grade Fused silica right angle prism units configured orthogonally to preserve polarization in a C-mount housing	PH00053
COL-FXT 250 TEL-X	250 mm FL collimation fixture 1550nm	PH00071
COL-FXT CO2	Collimation Fixture for 10.6µmWL	PH00072
RAL-FXT	Rayleigh fixture for manual M2	PH00073
RSP100	RailScan motion stage 100mm length	PH00078
RSP200	RailScan motion stage 200mm length	PH00079
RSP500	RailScan motion stage 500mm length	PH00080
H-I LA	Modify H-I for Large (100mm) Scan head	PH00082
H-I 980-VIS w/lens	NS lens mount bracket and 60X lens 980 WL	PH00146
H-I 1550 w/ lens	NS lens mount bracket and 40X lens 1550 WL	PH00081
H-I High energy IR	NS lens mount bracket w/ high energy lens WLxxx	PH00147
H-I 100X	NS lens mount bracket and 100X lens WLxxx	PH00148

Power attenuation options

ND stand for Neutral Density, a term used in photography to designate that a specific filter will attenuate all wavelengths across the visible equally or neutrally. This is the name given to the Wratten type 96 filters, which come in various Optical Densities, ND1, ND2, ND0.5, etc. however, the proper term for beam profiling is Optical Density, so the options should be OD1, OD2 etc.

Item	Description	P/N
HP-ND1 350 thru 399nm	Must be ordered w/new system – Si only	PH00370
HP-ND1 400 thru 700nm	Must be ordered w/new system – Si only	PH00371
HP-ND2 400 thru 700nm	Must be ordered w/new system – Si only	PH00372
HP-ND3 400 thru 700nm	Must be ordered w/new system – Si only	PH00373
HP-ND1 750 thru 890nm	Must be ordered w/new system – Si & Ge only	PH00374
HP-ND2 750 thru 890nm	Must be ordered w/new system – Si & Ge only	PH00375
HP-ND3 750 thru 890nm	Must be ordered w/new system – Si & Ge only	PH00376
HP-ND1 900 thru 1100nm	Must be ordered w/new system – Ge only	PH00377
HP-ND2 900 thru 1100nm	Must be ordered w/new system – Ge only	PH00378
HP-ND3 900 thru 1100nm	Must be ordered w/new system – Ge only	PH00379
HP-ND1 1150 thru 1600nm	Must be ordered w/new system – Ge only	PH00380
HP-ND2 1150 thru 1600nm	Must be ordered w/new system – Ge only	PH00381
HP-ND3 1150 thru 1600nm	Must be ordered w/new system – Ge only	PH00382

3.4 Accessories for Beam Profiling

Introduction

Spiricon has the most extensive array of accessories for beam profiling existing. There are components for attenuating, filtering, beam splitting, magnifying, reducing and wavelength conversion. There are components for wavelengths from the deep UV to CO_2 wavelengths. Most of the components are modular so they can be mixed and matched with each other to solve almost any beam profiling requirement needed.

3.4.1 Neutral Density Attenuators/Filters

For almost all applications, the laser beam intensity is too high for the operating range of the CCD. Therefore ND glass attenuator filters are available to reduce the intensity to the proper level at the CCD. In general, either the LBF-50 attenuating filer set or a set of individual, stackable, screw on filters is recommended. These filters are carefully designed not to affect beam quality or cause interference effects. One stackable ND1 filter and 2 ND2 filters are supplied standard with each camera.

Model	Stackable ND Filters ND1/ND2/ND3	LBF-50	Continuously Variable	ATP-K Variable Attenuator	UV ND Filters	Speciality Filter for 355nm	Speciality Filter for 1300nm
Nominal ND value	1,2,3	0.3, 0.7, 1, 2, 3, 4	1-6 continuously variable	ND=1.7-4.6 Max. ND: 7.4 (with fixed 2.8 gray-glass attenuator)	0.3, 0.7, 1.0, 1.3, 1.7, 2.0, 2.3, 2.7, 3.0, 3.3, 3.7, 4.0, 4.3, 4.7, 5.0, 6.0	Pass 355nm, blocks 532nm & 1064nm	Pass 1300nm, blocks <1100nm
Clear aperature	Ø19mm	Ø12mm	Ø20mm	Ø15mm	Ø20mm	Ø19mm	Ø19mm
Damage threshold	5W/cm² no distortion	5W/cm² no distortion	5W/cm² no distortion	100mW/mm no thermal lensing	100W/cm² CW, 10ns pulses, no distortion	5W/cm² no distortion	5W/cm² no distortion
Mounting	C-Mount Threads	C-Mount Threads	C-Mount Threads	C-Mount Threads	C-Mount Threads	C-Mount Threads	C-Mount Threads

Stackable ND filters

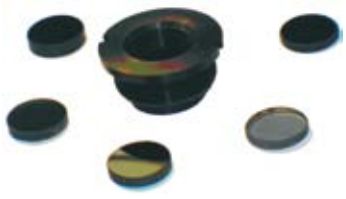
The individual filters come in three versions, the ND1 filter in the red housing with ~10% transmission in the visible, the ND2 filter in the black housing with ~1% transmission and the ND3 filter in the green housing with ~0.1% transmission. The individual filters can be screwed on top of each other and thus stacked.
They are set at a small wedge angle in the housing so as not to cause interference effects.

ND1, ND2 and ND3 stackable filters

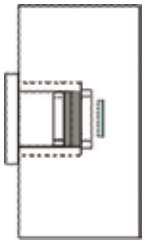
Stackable filter showing wedge

LBF-50

The LBF-50 comes with a set of filters that are inserted into the flange shown, mounted on top of each other and secured.
A set of 6 filters is provided that can achieve attenuation anywhere from ND 0.3 to ND 8. The LBF-50 is especially useful for CS or C mount cameras with the CCD recessed way below the surface. The filters are recessed into the camera thus saving thickness as shown in the illustration to the right.



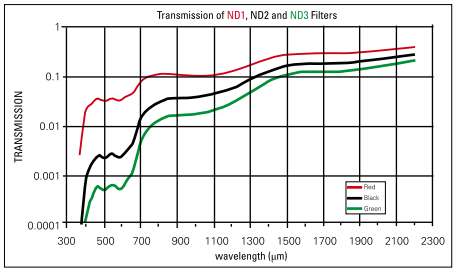
LBF - 50 filter assembly



LBF-50 on C mount camera

Transmission vs. Wavelength

These "neutral density" or ND filters do not have a flat response in attenuation vs. wavelength. See the graph for typical transmission vs. wavelength characteristics.

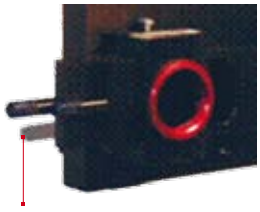


Specifications

Item	ND1 / ND2 / ND3	LBF-50
Nominal ND (vis)	1, 2, 3	0.3, 0.7, 1, 2, 3, 4
Clear Aperture	Ø19mm	Ø12mm
Damage threshold	5W/cm², 1J/cm² for ns pulses	

Continuously Variable Attenuator

For maximum ease of use there is the continuously variable attenuator that can vary its attenuation over a very wide range just by pushing and pulling the filters laterally. The attenuator consists of two opposite wedges of ND glass. The surfaces are arranged so that no parallel surfaces face each other so as to eliminate interference effects. The variable attenuator uses the same C-mount thread as the other components so it can be combined with additional stackable filters and beam splitters, if necessary, as shown.



Push/Pull to vary attenuation

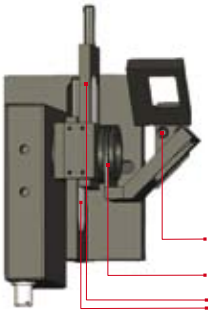
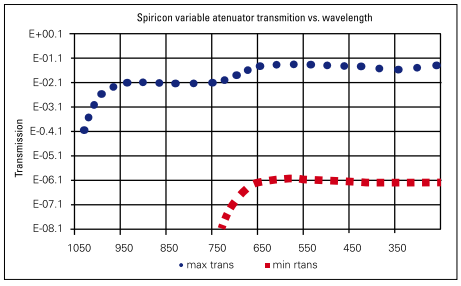


Illustration of variable attenuator mounted with additional filter and beam splitters



Specifications

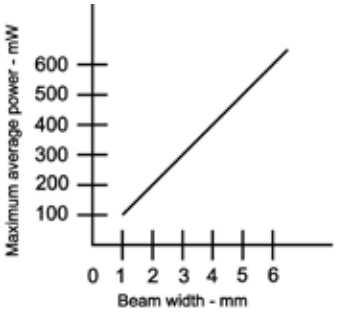
Item	Variable attenuator
Nominal ND (vis)	1 - 6 continuously variable
Aperture	Ø20mm
Optical quality	2 waves in visible
Damage threshold	5W/cm², 1J/cm² for ns pulses

ATP-K Variable Attenuator

This option makes beam profiling easy. The ATP-K attenuates your laser without ghost reflections or fringes and has a knob-operated variable wedge attenuator of ND 1.7–4.6, and comes with a fixed gray-glass attenuator with ND 2.8.
The ATP-K is also designed to be used with the HP-XXX high power attenuators and beam splitters. Both types of attenuators attach directly to the ATP-K via C-mount. The ATP-K has simple reproducible attenuation settings, and has a wavelength range of 360 to 2500+ nm.

Figure 1 below shows the safe average power for negligible beam distortion from thermal lensing. Absorptive filters, such as used in the ATP-K have an upper power limit of approximately 100mW per mm beam diameter. For pulsed beams, Figure 2 shows the damage threshold for energy where breakage of the glass wedge may occur. This is approximately 5J per mm beam diameter. For lasers with power or energy levels above this the first stage of attenuation will need to come from our line of high power reflective attenuators.

Figure 1 – Safe average power for negligible beam distortion



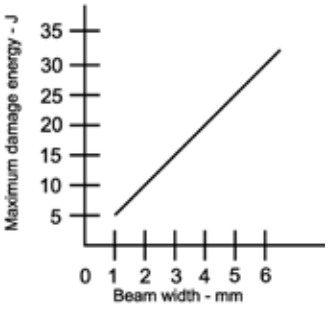


Figure 2 – Point at which damage will occur with pulsed energy

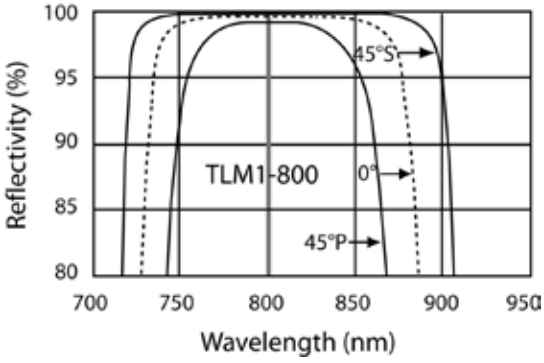
ATP-K Specifications	
Maximum Power/Energy Handling	100 mW/mm beam diameter 100 mJ total avg. energy Damage threshold: 5J
Note: Powerful laser sources may require additional attenuation prior to the beam's exposure to Model ATP-K. Additional attenuation usually is achieved by use of high-power laser mirror attenuators or clean, high-quality quartz plates (recommended with slight wedge angles).	
Wavelength Range	360-2500+ nm Near flat response out to 1500nm
Attenuation Range	Variable filters: ND = 1.7 to 4.6 Maximum ND 7.4 (with fixed 2.8 gray-glass attenuator)
Note: ND (optical density) = log (1/T) or T=10 (-ND) where T is the fraction of light transmitted. For example, an ND of 5 transmits 0.00001 or 0.001%.	
Clear Aperture	15mm diameter
Dimensions	94 (W) x 28 (H) x 43 (D) mm
Thickness Tolerance	±0.25mm
Mounting	C-mount
Base Mount	¼-20

High Power Attenuators

Our high-power laser mirror attenuator transmits <1%, and comes in a C-Mount threaded adapter ring. It is also AR coated for either straight on or 45° orientation.

Available standard configurations:

- HP-266 — Use for 266 ±50nm
- HP-355 — Use for 350 ±50nm
- HP-450 — Use for 450 ±50nm
- HP-600 — Use for 500–700nm
- HP-800 — Use for 700–900nm
- HP-1064 — Use for 1000–1100nm



Other wavelengths available upon request.
Note that if more than one reflective attenuator is required to reduce the beam power, one of them must be oriented 45° to the beam. Unlike absorptive attenuators, reflectors cannot be stacked, because they will form a laser cavity.

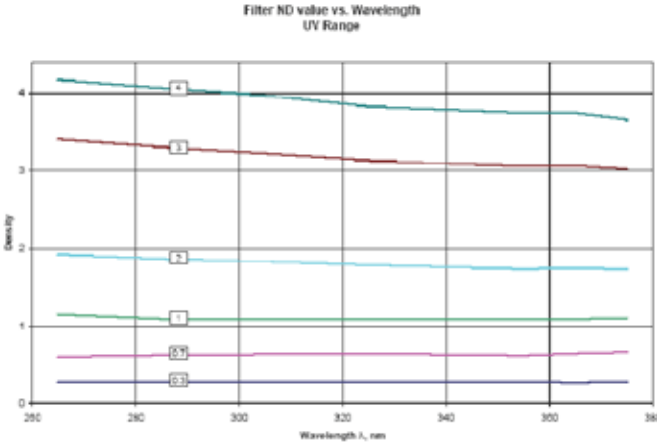
UV ND Filters

This accessory can be used with any camera fitted with C- mount threads. Simply thread the attenuator assembly into the front of the camera and then slide the ND filter arrays to get the desired amount of attenuation. This device can be used with laser outputs from microwatts to Watts. Three filter holders are provided with two filters in each holder. Each filter in the holder provides for a different value of attenuation. To use, slide the desired holder into the housing slot. A click is felt when the filter is properly aligned with the beam. The holders provided will allow for attenuation of up to ND 6.

C-mount interface for universal application to our CCD and Pyroelectric cameras 190-380nm attenuation covers Excimer, Helium Cadmium, and the Nd:YAG UV harmonic laser wavelengths.
Attenuation with these ND filters permits the best use of the dynamic range of a beam profiling camera.
Attenuation range of 0.3 to 6.0 optical densities (ND).
Set consists of three slides with two filters in each slide.
The Six Filters include 0.3, 0.7, 1.0, 2.0, 3.0 and 4.0 optical densities.
Two filters can be employed at one time for 0.3 – 6.0 optical attenuation in 0.3 or 0.4 ND steps.
20mm clear aperture will not vignette any of our applicable camera sensors.
Damage threshold = 100W/cm^2 for CW lasers and 20mJ/cm^2 for nano-second pulse width lasers.
Additional Beam Splitters can be added for attenuation of high power UV lasers.
UV attenuation system uses high quality optics from the leader in laser beam diagnostics.

Specifications

Item	UV ND Filters
Nominal ND (UV)	0.3, 0.7, 1.0, 1.3 ,1.7, 2.0, 2.3, 2.7, 3.0, 3.3, 3.7, 4.0, 4.3, 4.7, 5.0, 6.0
Aperture	Ø20mm
Damage threshold	100W/cm^2 CW, 10ns pulses, no distortion



Specialized Filters

There are also specialized filters available to eliminate extraneous wavelengths when measuring very short or very long wavelengths where the CCD cameras are not sensitive and the desired signal can get swamped by extraneous light of other wavelengths.
These filters are as follows:

1. The 355nm filter for monitoring the 3rd harmonic of YAG. This filter transmits 355nm but blocks 532nm and 1064nm.
2. The 1300nm filter transmits1300nm but blocks wavelengths shorter than 1100nm.

These filters are also on the same standard thread so they can be mixed with all the other components.
See ordering information pages for more details.

Ordering Information

Item	Description	P/N
ND1 stackable filter (red housing)	4mm spacing screw on filter for camera with transmission of between 20% and 5% depending on spectral range. Can be stacked and combined with other filters and beam splitters.. One filter is included with Spiricon cameras.	SPZ08234
ND2 stackable filter (black housing)	4mm spacing screw on filter for camera with transmission of between 7% and 0.5% depending on spectral range. Can be stacked and combined with other filters and beam splitters. Two filters are included with Spiricon cameras.	SPZ08235
ND3 stackable filter (green housing)	4mm spacing screw on filter for camera with transmission of between 2% and 0.05% depending on spectral range. Can be stacked and combined with other filters and beam splitters.	SPZ08253
LBF-50 filter set	Compact screw in filter holder with set of ND filters. Attenuations from low to 106.	SP90081
Filter holder and 50x50 filter set	Filter holder with set of 4 standard Schott 50X50mm neutral density filters. Useful to reduce intensity before inputting into 4X beam reducer. Mounts to standard ¼" thread, ½" diameter laboratory rod.	SPZ08240
Variable filter	Continuously variable filter for complete control over beam intensity. Especially useful for pulsed lasers. Varies the intensity over more than 4 orders of magnitude between wavelengths 350nm and 1100nm. Can be stacked and combined with other filters and beam splitters.	SPZ17012
ATP-K	Variable Attenuator Package provides smooth knob operated variable wedges with attenuation of optical density (ND) 1.7–4.6 for a total attenuation capability of ND 7.4. Specially designed to eliminate ghost reflections, fringes, and light leaks. Small compact module including C-mount adapter to attach to camera, and C-mount receptacle to easily attach additional HP-series attenuators.	PH00128
HP-266	High power laser grade fused silica reflective mirror attenuator for UV applications at 266nm. Second surface anti-reflection coated. Transmits <1%. Useful 266 ±50nm.	PH00129
HP-355	High power laser grade fused silica reflective mirror attenuator for UV applications at 355nm. Second surface anti-reflection coated. Transmits <1%. Useful 355 ±50nm.	PH00130
HP-450	High power laser mirror attenuator for applications in the visible from 400-500nm. Second surface anti-reflection coated.Transmits <1%. Useful 450 ±50nm.	PH00131
HP-600	High power laser mirror attenuator for applications in the visible from 500-700nm. Transmits <1%.	PH00132
HP-800	High power laser mirror attenuator for applications in the visible-Near IR from 700-900nm. Transmits <1%.	PH00133
HP-1064	High power laser mirror attenuator for applications in the Near IR from 1000-1100nm. Transmits <1%.	PH00134
UV ND Filters	3 Filters holders each with 2 inconel UV ND. Filters for attunation up to ND 6.	SP90228
Filter for 355nm-V2; give an undistorted image of the 355nm light	Silicon cameras can see the 355nm 3rd harmonic radiation of YAG. The YAG however usually emits some light at 532nm and 1064nm as well. This filter filters out the other 2 wavelengths to give undistorted image of the 355nm light.	SPZ08246
Filter for 1300nm	For all cameras that can operate at 1300nm but are quite insensitive there. This filter filters out all light below 1100nm to allow viewing 1300nm radiation without background interference.	SPZ08242

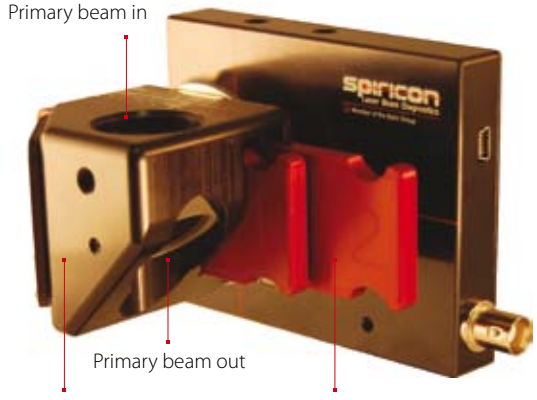
3.4.2 Beam Splitter + Neutral Density Filters Combo

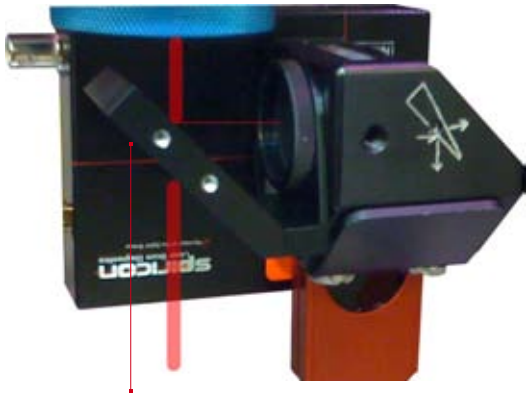
The attenuators described before can provide a high degree of attenuation however, these neutral density attenuators cannot dissipate more than 5W or so. Therefore we often place beam splitters in front of the attenuators to reduce the intensity before the ND filters. These beam splitters are made of UV grade fused silica for use from 190 to 2000nm. Since they do not absorb light, they have a much higher power handling capacity than the ND attenuator/filters.

Model	LBS-300	LBS-100
Wavelength	multiple versions from 190 to 1550nm	multiple versions; 400-900nm, 1064nm, 10.6µm
Reflection	0.01% of incident beam	4% @ 400-900nm, 1% @1064nm, 0.5% or 5% @10.6µm
Nominal ND value (vis)	0.3, 0.7, 1, 2, 3, 4	0.3, 0.7, 1, 2, 3, 4 for 300-900nm & 1064nm 30% & 60% for 10.6µm
Clear aperature	Ø17.5mm	Ø19mm
Damage threshold	see spec sheet	5W/cm² no distortion
Mounting	C-Mount Threads	Lab post mounted

LBS-300 Beam Splitters

The LBS-300 beam splitter attachment for C-mount, CS-mount, or Ophir mount cameras allow you to measure laser beams with diameters up to 15mm and powers ranging from 10 mWatts to ~400 Watts. The beam sampler is designed so that the preferential polarization selection effect of a single wedge is cancelled out and the resulting beam image is polarization corrected to restore the polarization components of the original beam. The beam sampler operates by reflecting the incoming beam from the front surfaces of a pair of wedges through 90 degrees into the camera. Approximately 99% of the beam is transmitted through the beam sampler with 0.01% passed on to the camera. A set of adjustable ND filters are provided to make final intensity adjustments to the beam before it reaches the camera imager. As an option, you may order the WVF-300 (P/N SP90195) continuously variable ND filter set that can slide in and replace the fixed ND filters. If additional attenuation is needed, an external wedge (P/N SPZ17015) may be mounted at the input port, however this 3rd wedge will cause polarization selectivity when the beam is significantly polarized different in the S and P planes. Alternatively, two LBS-300s can be coupled in series providing up to a 10^{-8} attenuation.


Primary beam in
Primary beam out
2 - 45° wedges to reflect the primary beam into the camera
Selection of 4 adjustable ND filters



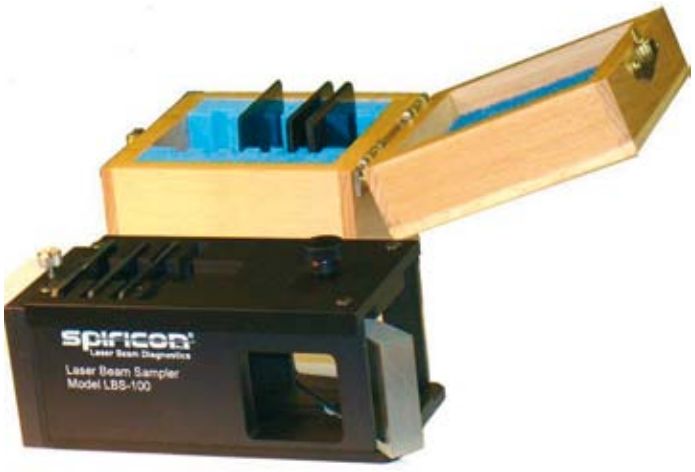
Ordering Information

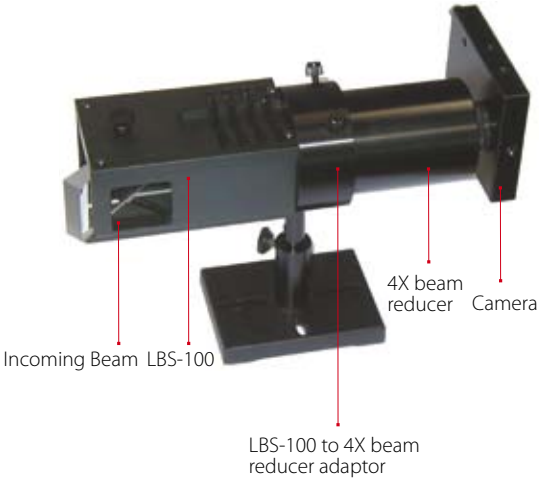
Model	LBS-300-UV	LBS-300-VIS	LBS-300-NIR	LBS-300-BB
Part No.	SP90183	SP90184	SP90185	SP90186
Wavelength	266-355nm	400-700nm	1064nm	190-1550nm
Wedge Material	UVFS	BK7	BK7	UVFS
Wedge Coating	A/R ≤1%	AR ≤1%	AR ≤1%	No coating, 4% reflection
Clear aperture	17.5mm	17.5mm	17.5mm	17.5mm
Reflection	0.01%	0.01%	0.01%	0.16%
Wedge ND value, each	ND ≥2	ND ≥2	ND ≥2	ND ~1.3
ND Filters	Inconel	Bulk ND	Bulk ND	One each of the UV, VIS & NIR sets
ND Values, nominal	0.3, 0.7, 1.0, 2.0, 3.0, 4.0 (Blu holders)	0.3, 0.7, 1.0, 2.0, 3.0, 4.0 (Grn holders)	0.3, 0.7, 1.0, 2.0, 3.0, 4.0 (Red holders)	See UV, VIS and NIR descriptions
Filter Slides	3	3	3	9
Maximum allowable input to filter (1)	100 W/cm² CW 20mJ/cm², 10ns pulse	50 W/cm² 1J/cm², 10ns pulse	50 W/cm² 1J/cm², 10ns pulse	See adjacent specifications
Accessories				
Wedge Variable ND Filter kit	N/A	WVF-300 SP90195	WVF-300 SP90195	WVF-300 SP90195
Beam Dumps	BD-040-A, 40 Watts Max Power, Air Cooled			SP90192
	BD-500-W, 500 Watts Max Power, Water Cooled			SP90193
Beam Deflector Assemby	for 400-1100 nm only			SP90263
Large C-mount Wedge Splitter	For additional attenuation add this to the front end of the LBS-300. Good for 350-2000nm			SP90273
Note: (1)	ND bulk absorbing filters damage threshold is 50W/cm² but should be used at <5W/cm² to avoid thermal lensing effects.			

LBS-100 Attenuator

The LBS-100 system that is not as compact as the LBS-300 above but has larger aperture, and has versions for longer wavelengths. The system contains the mounting frame, 1 wedge beam splitter and several attenuators. The exit end of the LBS-100 is standard C mount thread so all our cameras can be mounted to the frame. The wedge angle is 6.5 degrees to insure that the reflection from the rear side will not enter the camera. The optical elements are flat to 1/4 wave in the visible to insure no distortion of the beam.

LBS-100 System





The LBS beam splitter/attenuator system can be combined with the 4X beam reducer, as shown above, to attenuate and view large beams.

Ordering Information

Item	Wavelength range	Absorber material	Neutral Densities or transmission	Wedge material and reflection	Max power density on ND filters	Clear aperture	Dimensions	P/N
LBS-100	400 - 900nm recommended, functional to 2600nm	Neutral density glass	0.3, 0.7, 1.0, 2.0, 3.0, 4.0 ND at 632nm	Fused Silica 4% in wavelength range 400 - 900nm	5W/cm² for no distortion, 50W/cm² damage	19mm	65mm W x 55mm H x 140mm D	SP90061
LBS-100 YAG	1064nm	Same	Same	1% at 1064nm	Same	Same	Same	SP90057
LBS-100 IR 0.5	10.6µm	CaF2 flats,3 -3mm and 1-1mm	30% T for 3mm flat, 60% T for 1mm flat at 10.6µm	ZnSe 0.5% at 10.6µm	Same	Same	Same	SP90058
LBS-100 IR 5.0	10.6µm	Same	Same	ZnSe 5% at 10.6µm	Same	Same	Same	SP90059
LBS-100 to 4X beam reducer adapter	This adapter enables mounting of the LBS-100 beam splitter/attenuator assembly in front of the 4X beam reducer. The combined assembly can image large high power beams in one unit.							SPZ17029

3.4.3 Beam Splitter

Model	Beam Tap I & II	Beam Tap I & II YAG	Stackable Beam Splitter	Single & Dual Front-Surface Beam Samplers
Wavelength	400-700nm	1064nm	190-2000nm	200nm-2.5µm
Reflection	4% & 0.16% of incident beam	0.5% & 0.0025% of incident beam	5% & 0.025% of incident beam	0.057% @ 532nm
Clear aperature	Ø17.5mm	Ø17.5mm	Ø15mm	Ø14mm
Damage threshold	5W/cm² no distortion	5W/cm² no distortion	>5J/cm²	100MW/cm²
Mounting	C-Mount Threads	C-Mount Threads	C-Mount Threads	C-Mount Threads

Beam Tap I & II

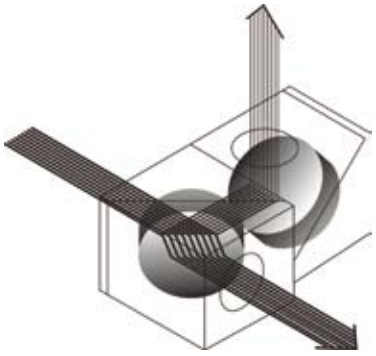
- Dual surface reflector for equalizing S & P polarization
- The two planes of reflection are orthogonal

Single Surface Polarization Problems

A single surface reflection at 45° is often used to sample a laser beam for profile measurements or for monitoring power or energy. However, as shown, at 45° a single surface reflects the S polarization component at more than 10 times the reflection of the P component. Depending on the laser polarization content, or stability, this sampling can provide very misleading and unreliable measurements. (The BT-I-YAG has both surfaces A/R coated for 1064nm so the reflection for both polarizations is equal at 0.5%. At other wavelengths far from 1064nm the above discussion applies).

Equalizing S & P reflected polarization

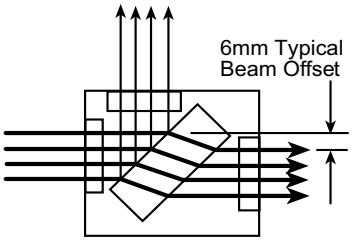
Any arbitrary polarization component can be broken into equivalent S & P components. With complimentary sampling surfaces any given component gets reflected once as the S polarization, and the second time as the P polarization. Thus using 2 surfaces, the total reflected energy for all polarization components is the sum of the **S** reflectance and the **P** reflectance. This causes the sampled beam to have **S & P** components that are identical to the original beam.



Beam path through beam tap

The Beam Tap II uses two reflecting surfaces such that the two planes of reflection are orthogonal. The standard Beam Tap I rear surface is AR coated from 400-700nm.

This diagram shows the 6mm offset of the through beam that is created by the reflecting optic. The deflection angle of the output beam is less than 0.007 degrees. The rear surface of the flat is AR coated to maximize the throughput of the main beam. The standard Beam Tap II rear surface is AR coated for 400nm-700nm. The YAG version is AR coated for 1064nm on both surfaces.



Beam tap relection vs wavelength

Shown is the Beam Tap II final sampled reflection vs. wavelength.
As shown both the S & P reflection are nearly constant at 0.05% from the UV to the infrared.

Ordering Information

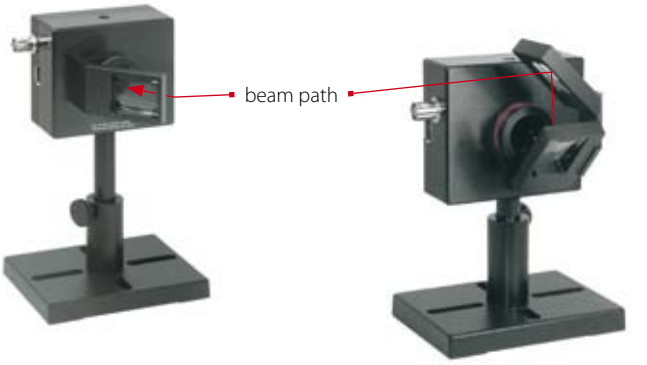
Model	Surface	Wavelength range	Optical Material	Reflection	P/N
BT-I	Single surface, 1 cube	400-700nm	UVFS	4% Ravg	SP90135
BT-II	Dual surface, 2 cubes	400-700nm	UVFS	0.16% Ravg	SP90133
BT-I-YAG	Single surface, 1 cube	1064nm	BK7	0.5% Ravg	SP90173
BT-II-YAG	Dual surface, 2 cubes	1064nm	BK7	0.0025% Ravg	SP90172

Stackable Beam Splitters

The stackable beam splitters are designed for maximum modularity and shortest beam path. They are compatible with almost all of our cameras having the standard C mount thread and can mount either to other attenuators or to the camera itself. Each beam splitter reduces the intensity of the beam by ~20 times (see graph below) so if a camera is equipped with filters that can operate with lasers typically up to ~1 Watt, with one beam splitter it can operate up to ~20 Watts and with two beam splitters up to ~400W. The Beam Splitters will operate for wavelengths from 190nm to 2000nm. The damage threshold of the beam splitters is >5J/cm^2 for 10ns pulses. The beam splitters are mounted over the fixed or variable attenuators with a simple fastening ring and can be oriented in any direction with the beam coming from right, left up, down ,or front.

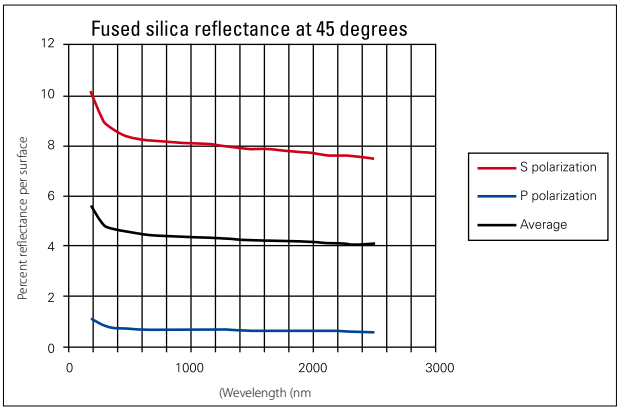
The wedge angle of 10 degrees insures that only the reflection from the front surface will appear on the camera with no double images. The user must insure that there are beam stops for the transmitted and reflected beams.

Note that if possible, the user should use an even number of beam splitters so as to cancel any possible polarization effects.



One beam splitter mounted

Two beam splitters mounted



Ordering Information

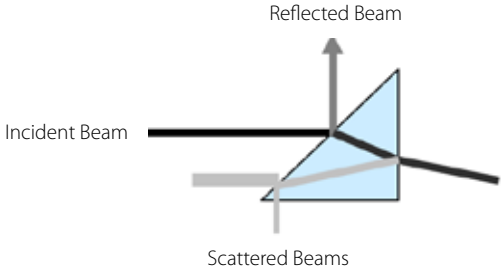
Item	Description	Aperture	Path length to CCD with 3 screw-on ND filters	P/N
1st Wedge Beam Splitter	45 degree wedged beam splitter to reduce intensities on image converter by ~20X. Aperture is 15mm	15mm(1)	60mm	SPZ17015
2nd Wedge Beam Splitter	Additional wedge beam splitter to mount to 1st wedge beam splitter		93mm	SPZ17026
(1) For converging beams a larger aperture 1st beam splitter is available P/N SPZ 17025. In that case, the aperture at the 1st beam splitter is 30mm				
Large aperture 1st Wedge Beam Splitter	For converging beams a larger aperture 1st wedge beam splitter. Aperture is 30mm	30mm		SPZ17025

With large beam splitter mounted showing how to image converging beam

Single and Dual Prism Front-Surface Beam Samplers

The Prism Front-Surface Beam Sampler (PFSA) is a C-mount fixture housing a UV-Grade Fused Silica right angle prism, used for sampling the front surface reflection for high power/energy beam-profiling applications. Reflection at nominal incidence of 45°is polarization and wavelength dependent, with 532nm s-polarization reflected at 8.27%, and p-polarization at 0.68%.

The system is available as either a single prism (PFSA) or dual orthogonal prism (DPFSA) unit. The dual orthogonal prism configuration results in polarization independent reflection of 0.057% at 532nm. Other filters and attenuators can be attached using the C-mount female threads at the input end. The use of a right-angle prism to sample the incident beam guarantees that any scattered secondary beams do not interfere with measurement, as shown in the sketch.



Dual Prism Front Surface Sampler

Prism Front Surface Attenuator Specifications

Wavelength of use	200nm to ~2.5um	
Optical Material	UV-Grade Fused Silica	
Surface Quality	20-10	
Surface Accuracy	λ/10	
Angle of Incidence	45°	
Clear Aperture	14mm x 14mm	
Reflection	Polarization	
λ (nm)	P	S
248.3	0.88%	9.40%
351.1	0.75%	8.65%
532	0.68%	8.27%
1064	0.64%	8.01%
Laser Damage Threshold	CW> 100MW/cm^2	
Dimensions(PFSA)	38.1mm x 32.3mm x 29.5mm	
Dimensions (DPFSA)	44.5mm x 40mm x 32.5mm	
Output Mounting with Brass Lock Ring	C-Mount Male (1"-32 Thread Male)	
Input Mounting	C-Mount Female (1"-32 Thread Female)	

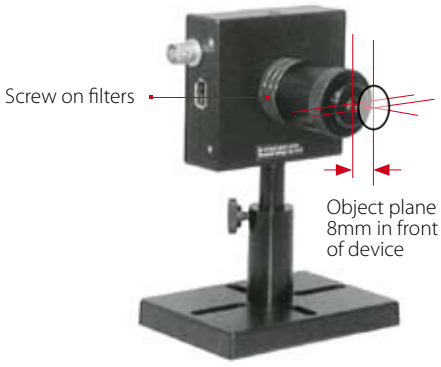
Two Single Prism Front Surface Samplers mounted on a ATP-K Attenuator

Ordering Information

Model	Surface	P/N
PFSA	Single Prism Front Surface Sampler	PH00052
DPFSA	Dual Prism Front Surface Sampler	PH00053

3.4.4 Beam Expanders Microscope Objectives

Model	4X Beam Expander with UV Converter	Beam Expander
Wavelength	193nm-360nm	400-1800nm
Beam Size Change	4X Expansion	4X, 6X, 12X, 22X
Clear aperture	1/4 the size of the CCD imager	
Mounting	C-Mount Threads	



Camera with 4X Beam Expander

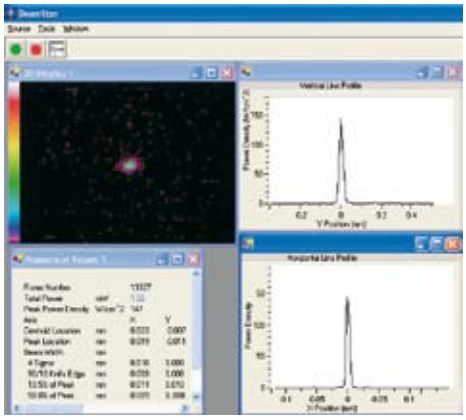
Beam expanders are available for 4.5mm spacing CS mount 12.5mm spacing cameras. The 4X beam expander is an expanding telescope that images the beam as it looks at 8mm from the end of the expander onto the CCD while enlarging the image 4X. In addition to the 4X beam expander, other microscope objectives are available for expanding the beam even more. There are objectives for 6X, 12X and 22X expansion. The various expanders allow the use of our 2% and 10% filters as well as the variable attenuator so as to accommodate the camera to a wide range of source intensities .

With a camera having 4.4µm pixel spacing using the beam expander, the effective resolution can be as good as 0.5µm. The object plane that is imaged onto the CCD is located several mm in front of the assembly so even hard to get to focal spots and other small images are easy to image. The beam expanders are designed to accommodate up to 3 screw on filters or a variable attenuator behind them so a wide range of intensities can be accommodated.

For intensities too large to be accommodated by just filters, beam splitters are available to reduce the intensity before the beam expander. The beam expander is primarily intended for nonparallel beams such as focal spots and fiber tips. If small parallel beams are imaged, interference effects may occur.

The 4X Beam expander can also be fitted with a UV converter plate at its object plane so that you can look at small beams in the spectral range 193-360nm and expand them 4X. See ordering information for further details.

Microscope objective assembly with beam splitter mounted



Shown is an image of the tip of a single mode fiber of 9µm diameter. The beam width as measured on the profiles shows 4X the actual size so we see a resolution of ~2µm.

UV converter assembly for 4X Beam Expander

Approximate expansion ratio	Spectral range	Distance from lens barrel to focus	Distance from focus to 1st beam splitter	Distance of closest approach to focus with 1 beam splitter	Total length of assembly
4X	400 - 1800nm	8mm	18mm	32mm	50mm
6X	600 - 1064nm	16mm	10mm past 1st surface	4.5mm	107mm
12X	600 - 1064nm	6mm	6mm	20mm	101mm
22X	600 - 1064nm	2.4mm	8mm	22mm	102mm

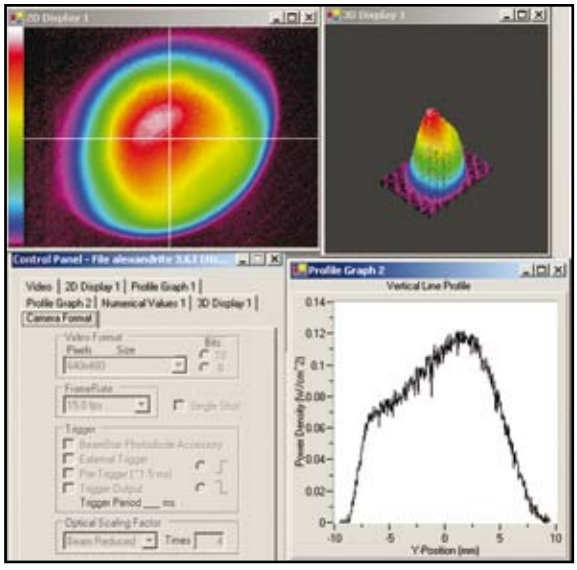
Ordering Information

Item	Description	P/N
4X reimaging beam expander	Screw optical assembly that images the plane 8 mm in front of the expander onto the CCD while enlarging it 4X. Fits 4.5mm recess and CS mount cameras.	SPZ17022
Fiber adapter bracket for 4X beam expander	Screw on bracket to use with Ophir fiber adapters so fiber is held in correct position to image fiber tip onto camera. Will give exact focus with FC type fiber.	SPG01649
UV converter assembly for 4X beam expander	Screw on assembly which has UV plate that converts 193 - 360nm radiation to visible. This plate is at the object plane of the 4X expander so it produces a 4X enlarged image on the CCD.	SPZ17019
6X expanding microscope objective	Screw optical assembly that images the plane 16mm in front of the lens onto the CCD while enlarging it ~6X. Fits 4.5mm recess and CS mount cameras. Needs spacer assy below.	SPZ08257
12X expanding microscope objective	Screw optical assembly that images the plane 6mm in front of the lens onto the CCD while enlarging it ~12X. Fits 4.5mm recess and CS mount cameras. Needs spacer assy below.	SPZ08259
22X expanding microscope objective	Screw optical assembly that images the plane 2.6mm in front of the lens onto the CCD while enlarging it ~22X. Fits 4.5mm recess and CS mount cameras. Needs spacer assy below.	SPZ08260
Spacer assy for objectives	Spacer assembly for above. One only needed for all expanders above.	SPZ08261
Beam splitter for expanders above	45 degree angle wedge beam splitter which mounts onto beam expander. Reduces beam intensity by ~20 times. For spectral range 190 – 2500nm. Introduces 35mm extra beam path to object plane.	SPZ17027
Additional beam splitter for above	Additional beam splitter to mount to 1st beam splitter.	SPZ17026

3.4.5 Beam Reducers

4X Reimaging Beam Reducer

The 4X Beam Reducer is an imaging system that images the plane 30cm in front of the reducer onto the camera CCD sensor while reducing the size 4 times and inverting it. The beam reducer uses the 3 screw on attenuators provided with the camera. Since the intensity of a beam after reduction will be increased by 4x4=16 times, it is advisable to attenuate the beam more than you would without beam reduction. This can be done with additional external beam splitters and attenuators which are available (see ordering information).
Note that the custom designed beam reducer gives better image quality than tapered fibers since it does not introduce graininess or uneven pixel response. Also the image distortion of ~1% is considerably lower than with most tapered fibers. The beam reducer is not compatible with CS mount cameras.



Shown is an image of an Alexandrite laser with beam diameter of 18mm. As can be seen, it is easily seen with the FX50 camera with the 4X beam reducer.

4X beam reducer

LBS-100 combined with 4X beam reducer

The 4X beam reducer can be combined with the LBS-100 beam splitter/attenuator system to attenuate higher power beams before reducing them in size

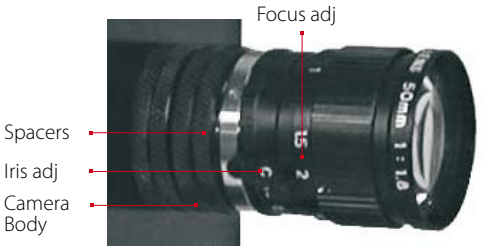
Specifications of 4X beam reducer	
Spectral Range	390nm to 1100nm
Antireflection Coating	Antireflection coating optimized for 1064nm and 532nm
Beam reduction Accuracy	± 3%
Size	Ø60 mm dia x 94mm length
Aperture	50mm
Maximum Beam Size	SP 503/FX50: 25x19mm, FX 33: 18x14mm, SP 620 or GRAS20: 28x21.2mm
Distortion of Beam	Less than 1% over 80% of diameter
Damage Threshold	30mJ per pulse for nanosecond pulses

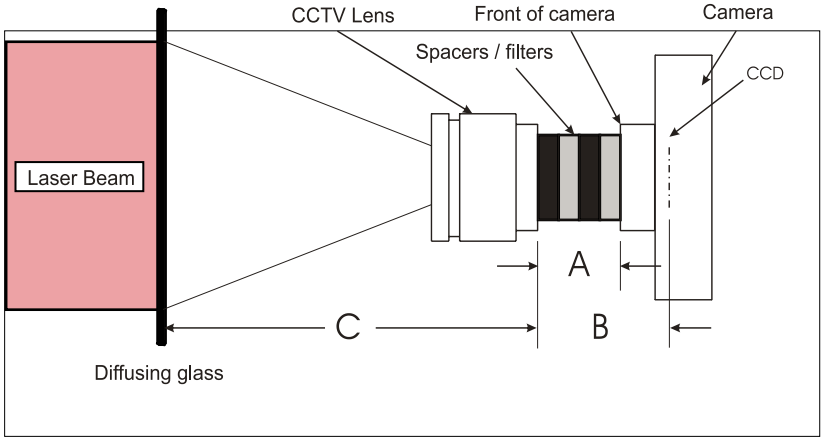
Ordering Information

4X Imaging Beam Reducer		
Item	**Description**	**P/N**
4X reimaging beam reducer	Screw on beam reducer for beams in the wavelength region 360 – 1100nm that reimages the beam 30cm in front of the unit onto the CCD while reducing the beam size 4X. Entrance aperture is 50mm. Fits 4.5mm recess cameras only.	SPZ17017
Accessories		
Filter holder and 50x50 filter set for 4X beam reducer	Filter holder with set of 4 standard Schott 50X50mm neutral density filters. Useful to further reduce intensity after beam splitter before inputting into 4X beam reducer. Mounts to standard ¼" thread, ½" diameter laboratory rod.	SPZ08240
LBS-100 to 4X beam reducer adapter	This adapter enables mounting of the LBS-100 beam splitter / attenuator assembly in front of the 4X beam reducer. The combined assembly can image large high power beams in one unit. See illustration on page163.	SPZ17029

3.4.6 CCTV lens for front imaging through glass or reflected surface

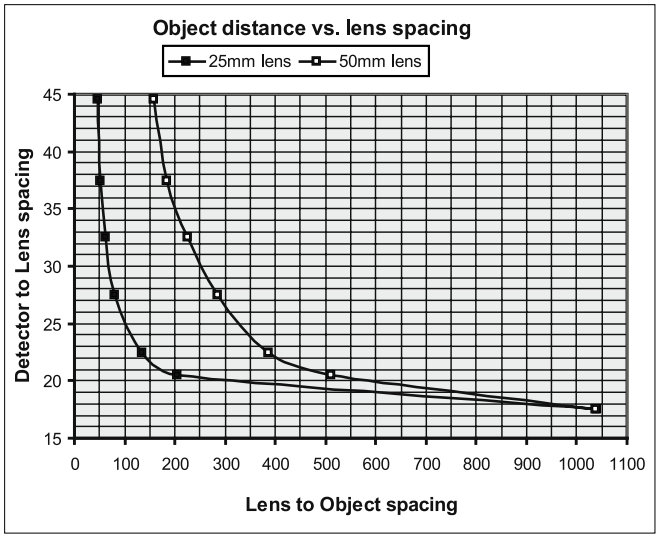
When direct imaging in front of the camera, for example, an image projected onto a diffusing surface, such as a ground glass plate, it is necessary to reduce the image so that it completely fits onto the CCD chip surface. The 25mm and 50mm CCTV lenses image an object from a given plane in front of the lens onto the CCD while reducing the size. The lens can image such objects at distances from about 10cm in front of the lens (20cm for the 50mm lens) to 1 meter or more depending on the distance from the lens to the camera. The distance from lens to camera depends on the camera type and spacers placed between the lens and the camera.

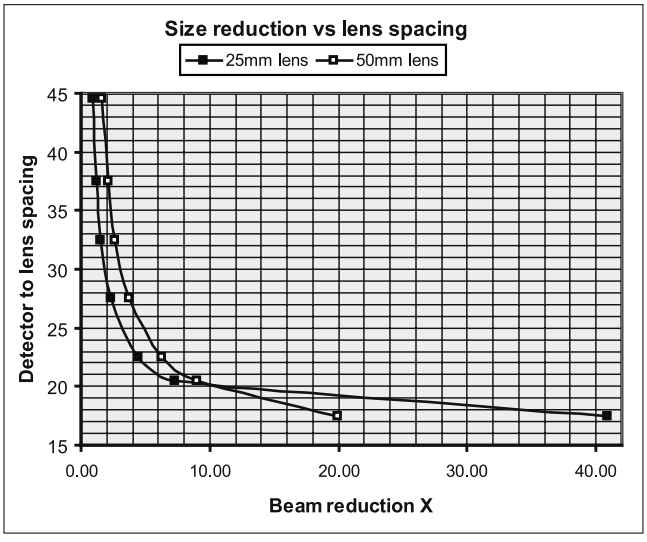




A. - Total length of spacers added to system
B. - Detector to Lens spacing. Distance 'A' plus the CCD inset for the camera type
C. - Lens to Object spacing

CCD inset for Camera Types
C mount (Camera front to CCD = 17.5mm) for nominal lens magnification, use without spacers.
CS mount (Camera front to CCD = 12.5mm) for nominal lens magnification, use 5mm spacer.
SP mount (SP cameras. Camera front to CCD = 4.5mm) for nominal lens magnification, use with 13mm spacers.





Ordering Information

Item	Description	P/N
25mm focal length CCTV lens kit	25mm focal length lens assembly with locking iris and focus adjustment. Includes 1 ea - 8mm spacer and 2 ea - 5mm spacers	SP90085
50mm focal length CCTV lens kit	Same as above except 50mm focal length lens	SP90038
4mm spacer	Screw on spacer to add 4mm spacing to optical system	SPG01698
5mm spacer	Screw on spacer to add 5mm spacing to optical system	SPG02106
8mm spacer	Screw on spacer to add 8mm spacing to optical system	SPG02067

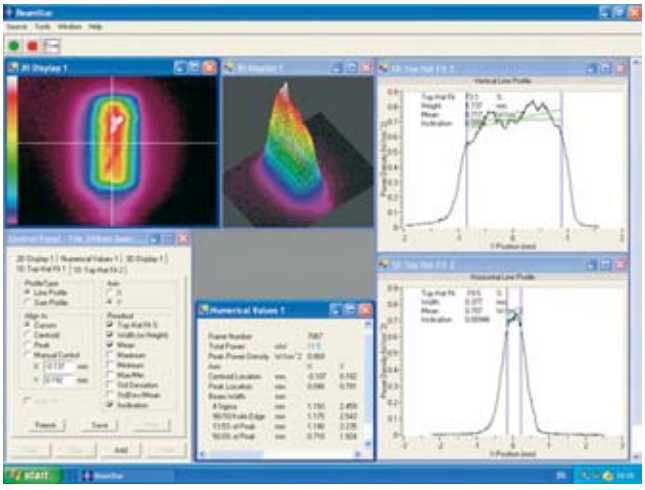
3.4.7 Imaging UV lasers

Integral Reimaging UV Image Converters

The UV image converters are fluorescent plates that convert UV radiation that is poorly imaged by silicon cameras into visible light that is then imaged onto the CCD of the camera. These fluorescent plates are specially designed for UV conversion and have a high light output, wide linear dynamic range and high damage threshold. There are 3 versions available:

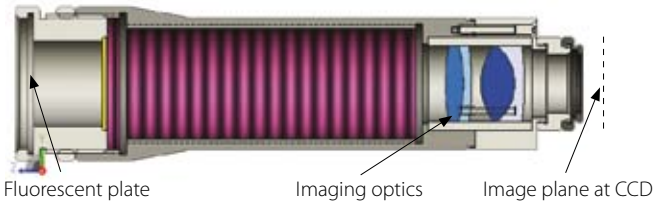
1. The 4X UV image converter for large beams converts to visible and then images onto the CCD while reducing the beam size 4X.
2. The 1:1 UV image converter converts to visible and images the beam onto the CCD without changing the size.
3. The 4X expander with UV converter converts to visible and images a beam enlarged 4X onto the CCD.

All of the above imagers allow a beam splitter to be mounted at 45 deg angle in front of the imager so as to allow imaging of higher power/energy beams.



Shown here is a profile of a 248mm Excimer laser beam

Cross section of 4X reducing UV image Converter



4X beam reducing UV Image Converter as mounted on camera

1X UV Image Converter with Optional Beam Splitter

4X beam expander with UV converter

Specifications	4X UV Image Reducing Converter	1X UV Image Converter	4X Beam Expander with UV converter
Beam Reduction	4X reduction ±2% with included correction factor	1:1 imaging ±2% with included correction factor	4X expansion ±2% with included correction factor
Resolution	50µm x 50µm	35µm x 35µm	15µm x 15µm
Spectral range	193 to 360nm		
Minimum signal	~1µJ/cm² with blank filter		
Saturation intensity	~30mJ/cm² at 193nm, ~15mJ/cm² at 248nm with included filter 20 times above values with optional beam splitter	~15mJ/cm² at 193nm, ~20mJ/cm² at 248nm with included filter, 20 times greater with optional beam splitter	~30mJ/cm² at 193nm, ~15mJ/cm² at 248nm 20 times above values with optional beam splitter
Effective Aperture	Ø30mm but effective beam size is limited to 4X CCD dimensions	Ø18mm but effective beam size is limited to CCD dimensions	1/4 the size of the CCD dimensions
Damage threshold	100W/cm² or 2J/cm² with beam splitter		
Dimensions	Ø50mm dia x 185mm length	Ø31mm dia x 120mm length	Ø29mm dia x 69mm length

Ordering Information

Item	Description	P/N
1X UV image converter	Screw on imaging telescope that converts UV image to visible and images same size on CCD. For beam intensities from 50µJ/cm² to 15mJ/cm². Fits 4.5mm recess and CS mount cameras.	SPZ17023
Beam splitter for above	45 degree wedged beam splitter to reduce intensities on image converter by ~20X. For beam intensities of up to 300mJ/cm² at 193nm.	SPZ17015
4X reducing UV image converter	Screw on imaging telescope that converts UV image to visible reduces the size 4X and images on CCD. For beam intensities from 1µJ/cm² to 15mJ/cm².	SPZ17024
Beam splitter for above	45 degree wedged beam splitter to reduce intensities on by ~20X. For beam intensities of up to 300mJ/cm² at 193nm.	SPZ17007
UV converter assembly for 4X beam expander	Screw on assembly which has UV plate to convert 193 - 360nm radiation to visible. The plate is at the object plane of the 4X expander (P/N SPZ17022) and produces a 4X enlarged image on the CCD.	SPZ17019
20mm diameter UV imaging plate	Ø20mm diameter UV image conversion plate only. For customers that have own imaging system. Converts UV image to visible. For beam intensities 50µJ/cm² to 10µJ/cm².	SPF01177
30mm diameter UV imaging plate	Ø30mm diameter UV image conversion plate only. For customers that have own imaging system. Converts UV image to visible. For beam intensities 50µJ/cm² to 10µJ/cm².	SPF01150
50mm X 50mm UV imaging plate	50X50mm diameter UV image conversion plate only. For customers that have own imaging system. Converts UV image to visible. For beam intensities 1mJ/cm² to 20mJ/cm². Not suitable for 193nm.	SP90082
100mm X 100mm UV imaging plate	100X100mm diameter UV image conversion plate only. For customers that have own imaging system. Converts UV image to visible. For beam intensities 1mJ/cm² to 20mJ/cm². Not suitable for 193nm.	SP90083

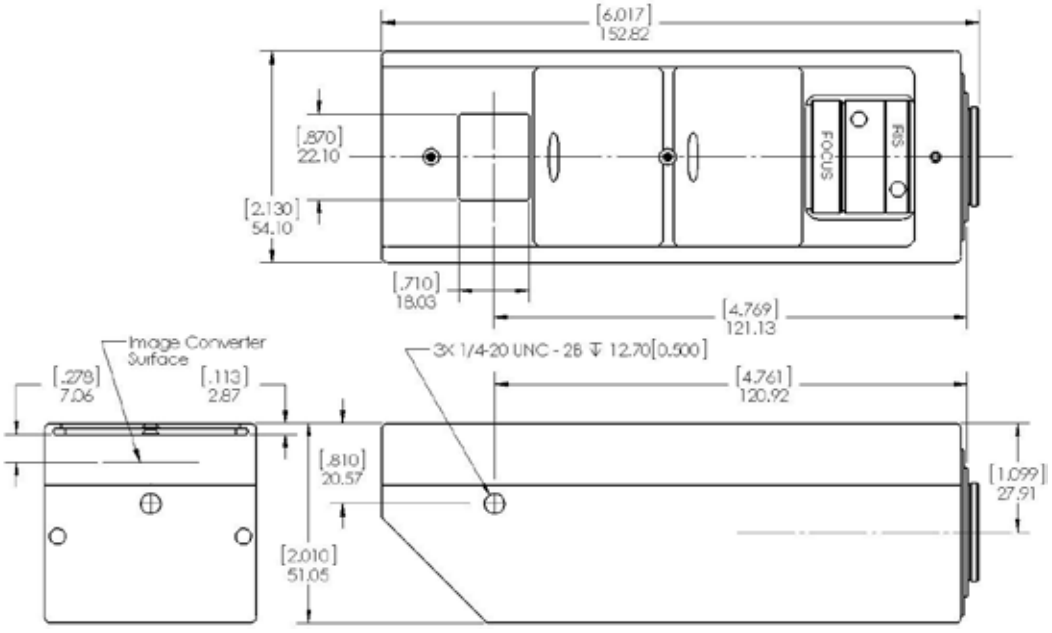
UView Ultraviolet Converter for C-mount Cameras

The UView accessory converts ultraviolet radiation into a visible green beam profile that is reimaged onto a CCD style C-mount camera. The UView operates over the ultraviolet region of 190-390nm. It has a reimaging magnification factor of ~0.5x and a field of view (FOV) of ~15x20mm with an SP620 style camera. The FOV will vary with camera format. Camera and software sold separately.

UView

UView- top view

UView- with camera (sold separately)



UView Image Converter specifications

Specifications	
Beam redactions	~ 0.50X nominal image reduction
Scale factor	~ 2.0 nominal scale factor for BeamGage, see label
Spectral range	190 to 390nm
Minimum signal	~ 1uJ/cm^2
Camera saturation[1]	~ 30mJ/cm^2 at 193nm, ~ 15mJ/cm^2 at 248nm Varies with wavelength and camera type
Clear apreture	18mm X 22mm
Effective apretute	15mm X 20mm w/SP620, varies with camera format
Damage threshhold	5W/cm^2 / 100mJ/cm^2
Mounting	3 1/4-20 threaded mounting points, see figure 11
Dimensions	see figure 7
Weight	Xxx oz. (yyy g)w/o camera
Adaptable beam analyzer camera systems	The Uview can be used with the following cameras employed by BeamGage, LBA and BeamStar products: (This product will work with any X/CS-mountcamera but the FOV will vary based on imager format) SP503, SP260, SCOR20, GRAS20, FX50, FX33, FX33HD, L070, L130, L230

1. The UV converter glass will damage before it becomes saturated

Ordering Information

Item	Description	P/N
UView	Uview, Accessory for C-mnt Cameras	SP90322

3.5 Near Field Profilers

3.5.1 Camera Based Near-Field Profiler

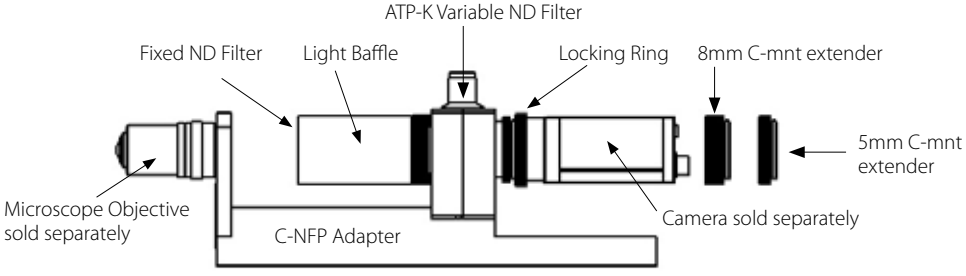
- Allows measurement of beams normally too small for camera profiler
- Expands beam to reduce power/energy density
- Provides near-field profile of fibers, LD junctions, and other small sources
- Can be used to measure tightly focused beam with camera and attenuation
- Nominal 10X, 20X, 40X, 60X Beam expansion available
- Easily calibrated to provide absolute measurement values
- Built-in continuously variable attenuation
- C-mount for attachment to any camera profiler
- Camera and BeamGage software purchased separately

Near field profiling can also be used with camera profilers to analyze small beams, and involves a microscope objective lens to image the beam onto a camera detector array. This technique expands the measurement range of the camera to include smaller beams, which could not be ordinarily measured due to the pixel size of the detector array. Near field profiling is performed in fiber and waveguide analysis, lens characterization, and other applications where beams 50 microns or smaller are analyzed. While there are more accurate techniques to measure these beam sizes, the camera provides two-dimensional information that cannot always be obtained through knife-edge or scanning slit methods. This camera accessory includes base plate for mounting camera and Microscope Objective, ATP-K variable attenuator, 50mm C-Mount and an 8mm and 5mm spacer. User selectable magnification lenses, camera and BeamGage must be purchased separately.

The near field of the test beam or sample is imaged with the microscope objective lens and relayed to the camera. The bracket mounting fixture holds both the lens and camera, which itself can be mounting on a positioner or optical rail. This complete system provides everything necessary to perform near-field measurements right out of the box.

Camera NFP with ATP-K Variable Attenuator

C-mount NFP Adapter Assembly



Ordering Information

Item	Description	P/N
C-NFP Assy	Includes base plate for mounting camera and Microscope Objective, ATP-K variable attenuator, 50mm C-Mount and an 8mm and 5mm spacer.	SP90291
60X	60X, Microscope objective	SP90292
40X	40X, Microscope objective	SP90293
20X	20X, Microscope objective	SP90294
10x	10X, Microscope objective	SP90295

3.5.2 Slit-Based NanoScan Near-Field Profiler

Measuring the near field of sources such as laser diodes, VCSELs, optical fiber, and/or waveguides can be a difficult task. Accurate measurement of such small sources to the micron level requires high precision in the optical and mechanical design. To simplify this task and to fill this requirement, Photon offers several models of Near-Field Profilers (NFPs) covering a wide range of wavelengths and power levels. Another important application of these instruments is to extend the focused laser spot size measurement range of the NanoScan profiler. By expanding the size of a focused spot it is possible to reduce the power density and make possible the measurement of beams that are too powerful to be measured without attenuation, as well as those that are too small to be accurately measured with the standard scanhead. The NanoScan NFPs are easy-to-use turnkey systems that can be used either as a stand-alone instrument or integrated into manufacturing inspection systems. For NanoScan users who want to extend the measurement capability of their present systems, the optical and mechanical components are also available as accessories.

The NFP-980 with 60:1 magnification and 1µm resolution, specifically designed for measurement of 980nm pump lasers, is also ideal for other applications in the wavelength range between 700nm–1100 nm. The NFP-1550, with 40:1 magnification and 2.6µm resolution, is designed for use in characterizing sources in the 1300-1600nm telecommunications wavelength band. Both models come with a NanoScan GE/9/5 scanhead and the magnifying objective lens, which can be rigidly mounted to an optional precision XYZ translation stage, which in turn is mounted to an optical rail. They also include the NanoScan Control and Data Acquisition Card and NanoScan Acquisition and Analysis Software. The system has all the standard Windows file saving, printing, communication and ActiveX capability.

For visible wavelengths, the NFP-VIS is equipped with the NanoScan SI/9/5 scanhead and the 60:1 microscope objective, AR coated for the 400–700nm wavelength range. UV Wavelengths below 360nm can also be accommodated with an optional UV corrected microscope objective. For higher power and longer wavelength beams the NFP-Pyro is available. These systems can measure spot sizes from 5µm at any wavelength from 190nm to 20µm. This instrument configuration naturally reduces the power density incident on the instrument by one over the square of the magnification. The system can be supplied with a lens for the user-specified wavelength of use.

For viewing VCSEL junctions, single-mode fibers and large long wavelength LD junctions there is an optional 100:1 objective lens option, producing diffraction limited performance from 400–700nm with a working distance of approximately 0.25-0.35mm and Numerical Aperture is 0.90. From 700–1600nm, this lens produces near diffraction-limited performance.

NanoScan Near-Field Profiler Systems

Parameter	NFP-VIS	NFP-980	NFP-1550	NFP-Pyro
Tester Wavelength Range	400-700nm <360nm optional	700-1100nm	1300-1700nm	190->20µm
Lens Spread Function	0.49µm	1.1µm	2.6µm	Wavelength and application dependent for these parameters
Maximum Source	140µm	140µm	200µm	
Objective Focal Length	3mm	3mm	5.1mm	
Objective Rear Focal Distance	160mm	160mm	207mm	
Objective Numerical Aperture	0.85	0.85	0.48	
Objective Magnification	60:01:00	60:01:00	40:01:00	
NanoScan Model	NSSI/9/5	NSGE/9/5	NSGE/9/5	NSPyro/9/5
Aperture Size	9mm	9mm	9mm	9mm
Slit Width	5µm	5µm	5µm	5µm
3 Axis Stage Travel				
X (across rail)	13mm micrometer adjust			
Y (normal to rail)	6.5mm fine pitch actuator			
Z (along rail)	13mm micrometer adjust			

Ordering Information

Item	Description	P/N
Model USB NFP-1550(NS)	Model NFP-1550 NanoScan system with Germanium Detector 9mm Aperture 5µm Slits. High-resolution 63.5mm diameter head with rotation mount. Use from 700nm to 1.8microns	PH00229
Model USB NFP-980(NS)	Model NFP-980 NanoScan Germanium Detector 9mm Aperture 5.0micron Slits. High-resolution 63.5mm diameter head with rotation mount. Microscope Objective Lens Mount with 60:1 optics for 700-1100nm	PH00230
Model USB NFP-VIS(NS)	Model NFP-VIS NanoScan Silicon Detector 9mm aperture 5µm slits. High-resolution 63.5mm diameter head with rotation mount. Microscope Objective Lens Mount Bracket with 60:1 optics for 400-700nm	PH00231
Model USB NFP-Pyro	NFP-NS-Pyro NanoScan pyroelectric detector with 9mm entrance 5µm slits. Use for wavelengths from 190mm to 20 microns (specify wavelengths of use when ordering). Lens Mount bracket with well-corrected aspheric high-energy 60:1 lens with a 0.68 NA. Available in wavelengths 400nm-1100nm	PH00232

3.6 What is M^2 ?

M^2, or Beam Propagation Ratio, is a value that indicates how close a laser is to being a single mode TEM_{00} beam, which in turn determines how small a beam waist can be focused. For the perfect Gaussian TEM_{00} condition the M^2 equals 1.

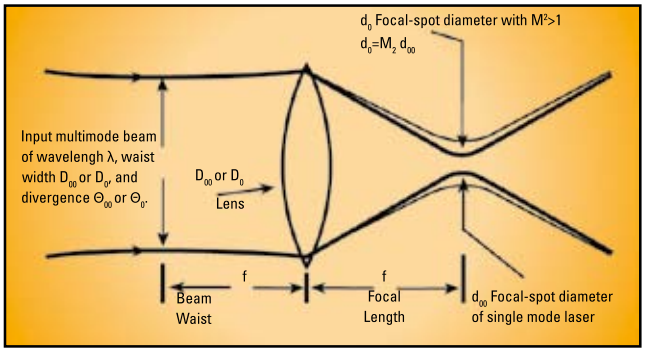
For a laser beam propagating through space, the equation for the divergence, θ, of an unfocused beam is given by:

$$\theta_0 = M^2 4\lambda/\pi D_0$$

For a pure Gaussian TEM_{00} beam M^2 equals 1, and thus has no impact on the calculation. The calculation of the minimal beam spot is then:

$$d_0 = 4\lambda/\pi\theta$$

Again with M^2 equal to 1, the focused spot is diffraction limited. For real beams, M^2 will be greater than 1, and thus the minimum beam waist will be larger by the M^2 factor.


d_0 Focal-spot diameter with $M^2>1$
$d_0=M_2\ d_{00}$
Input multimode beam of wavelengh λ, waist width D_{00} or D_0, and divergence Θ_{00} or Θ_0.
D_{00} or D_0
Lens
f
f
Beam Waist
Focal Length
d_{00} Focal-spot diameter of single mode laser

Characteristics of a laser beam as it passes through a focusing lens.

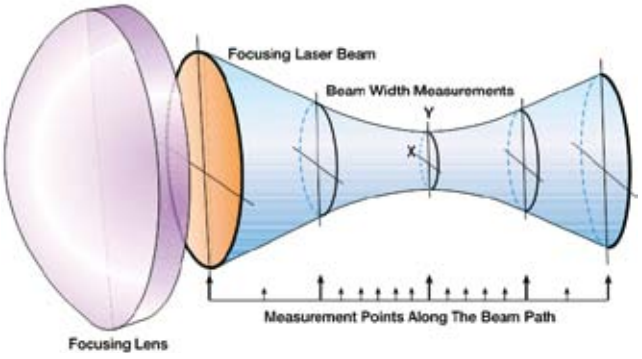
How is M^2 measured?

M^2 cannot be determined from a single beam profile measurement. The ISO/DIS 11146 requires that M^2 be calculated from a series of measurements as shown in the figure above. M^2 is measured on real beams by focusing the beam with a fixed position lens of known focal length, and then measuring the characteristics of the artificially created beam waist and divergence.

To provide an accurate calculation of M^2, it is essential to make at least 5 measurements in the focused beam waist region, and at least 5 measurements in the far field, two Rayleigh ranges away from the waist area. The multiple measurements ensure that the minimum beam width is found. In addition, the multiple measurements enable a "curve fit" that improves the accuracy of the calculation by minimizing measurement error at any single point. An accurate calculation of M^2 is made by using the data from the multiple beam width measurements at known distances from a lens, coupled with the known characteristics of the focusing lens.

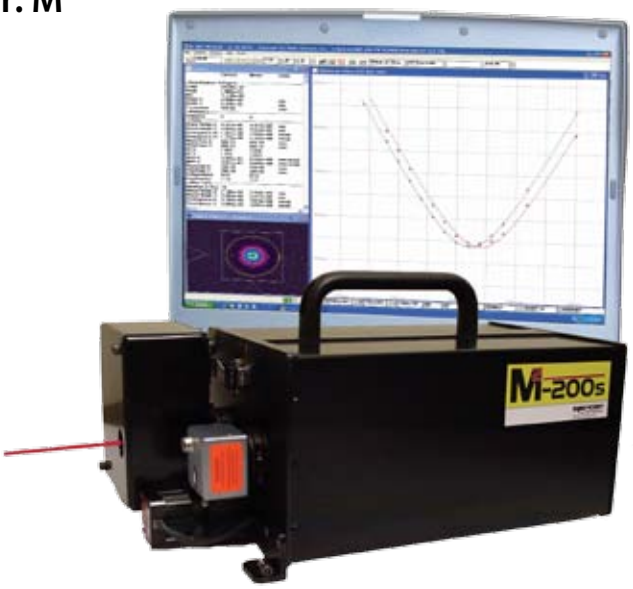
M^2 Measurement Solutions

Ophir-Spiricon and Photon have a number of solutions for the measurement of M^2 ranging from simple manual processes to fully automated dedicated instruments, depending on the frequency of the need to measure M^2 of lasers and laser systems. We have a system that will meet most needs, whether for research and development of new laser systems, manufacturing quality assurance, or maintenance and service of existing systems.



Camera Based Beam Propagation Analyzer: M^2

M^2-200s

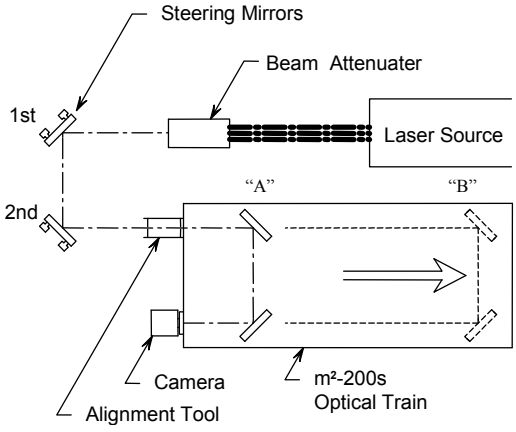


- Automatically measure your beam quality in under 2 minutes
- Tune your laser for best operation
- ISO compliant
- Specifically developed for continuous usage
- Unequaled accuracy using patented Ultracal™ Calibration
- Automatic attenuation adjustment
- Pulsed and CW for most beam diameters and powers
- Compact and portable

Not all commercial M^2 measuring instruments conform to the ISO 11146 method of employing a fixed position lens and moving detector. Instead, some manufacturers use a fixed position detector and a moving lens. If the laser beam is diverging or converging within the travel range of a moving lens, the reported M^2 value and other results can be significantly compromised. Spiricon's M^2-200s Beam Propagation Analyzer is fully ISO 11146 compliant.

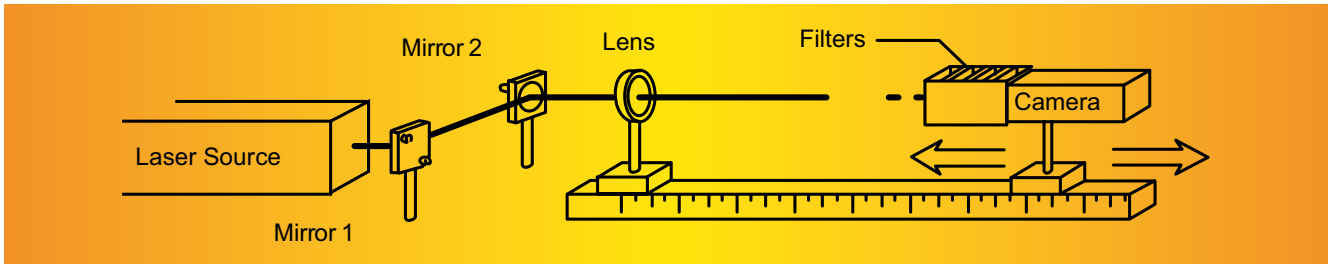
Automatic M^2 - at Production Speeds

The M^2-200s optical train uses a fixed position lens and camera. The mirrors that direct the focused beam into the camera are moved to precise locations, translating the beam through both the waist region and the far field regions. All these measurements and translations, as well as incremental beam attenuation, are automatically controlled by the M^2-200s software. Software improvements in the M^2-200s, including more efficient algorithm execution, has decreased the measurement reporting time by 2-3 times, making it possible to report M^2 in under two minutes.



Manual M^2

Manual mode is available for beams that are too large or too small or at wavelengths outside the standard optical train.



Accuracy by Design

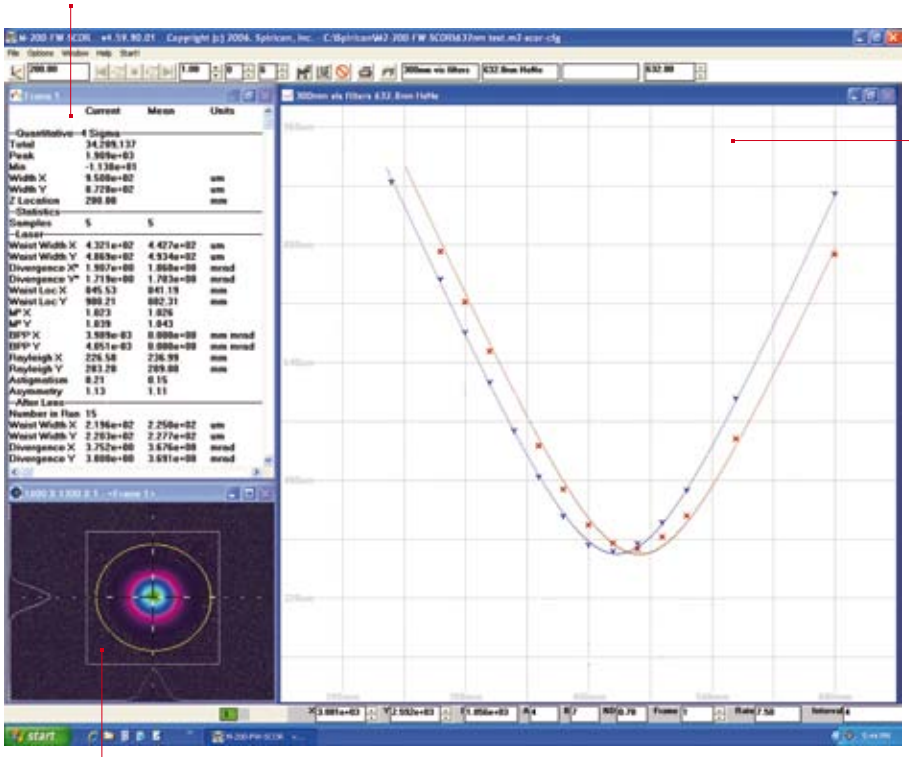
Spiricon products are known for accuracy. Using our patented Ultracal™ calibration method and auto aperturing to exclude noise beyond the wings of the laser beam, assures the user of the most accurate measurements in the industry.

Designed by Our Customers

Spiricon has redesigned the M^2-200, the world's top selling beam propagation system to include customer input, increased attention to durability, and operational robustness for continuous use applications - three shifts a day, seven days a week. Novice and seasoned users will appreciate these new features along with the time-tested excellence that the Spiricon M^2-200 measurement system has provided over the years.

Main Screen Functions

This window displays quantitative measurements of the laser parameters. These include the X and Y beam widths, M^2 or K, the divergence angles, the Rayleigh range, and other parameters shown.



This window presents measurements of beam width vs. position for a given run. After measuring a few points, the software extrapolates a curve fit. The Xs and Ys represent individual measurement points. The solid lines present the best fit hyperbola of the beam propagation equation to the measured points. The M^2 and other laser parameters are computed from the best fit hyperbola since it provides a smoothing of the data points.

The 2D or 3D beam profile of the currently measured point in the beam propagation curve. This image enables visual intuitive verification of the beam profile behavior through focus. After each run the user can click any individual measured point and observe the beam profile. Outlying or anomalous points can be automatically or manually excluded from the curve fit calculations for more accurate results.

3.6.1.1 Specifications for the M^2-200s

General	
Accuracy	±5% typical, ±12% waist location and Rayleigh length typical (Note: Accuracy can be degraded by a variety of situations)
Measurement Cycle Time	2-3 minutes typical, depending on setup conditions and operating mode
Camera Attachment	Std C-mount, 90° camera on axis rotation
Translation System	Step motor-driven lead screw
Translation Pitch	4 mm/rev optical pitch
Step Angle	1.8° (200 steps/rev)
Sample Range	M^2 - 200 s 190 - 600 mm, typical
Camera Specifications (for GRAS20 camera)	
Imager	1/1.8" CCD, 1600 x 1200 pixels
Dynamic Range	12 bit A to D
Frame Rates	7.5 FPS (at full resolution)
Pixel size	4.4µm x 4.4µm
Gain	0 to 25dB
Shutter Control	Programmable from 110µs to 70ms
S/N Ratio	59dB at min gain
Trigger Input	Edge sensitive 3.3 / 5Vdc LVTTL / TTL (positive or negative, user programmable)
	Minimum pulse width 10us
Trigger Out	External Trigger cable provided
Voltage Requirement	3.3Vdc LVTTL, Programmable
Power Consumption	Powered over Firewire Cable
	<3.5watts
Dimensions	44mm (1.74") wide, 29mm (1.14") tall and 66mm(2.6") deep
Mass	104g (3.7oz)
Environmental	
Storage Temperature	-30°C to 65°C
Storage Humidity	95% maximum (non-condensing)
Operating Temperature	10°C to 40°C
Operating Humidity	95% maximum (non-condensing)
Power Requirements*	
Line Voltage	95V AC to 250V AC
Line Frequency	47Hz to 63Hz
Maximum Power	4.5 Watts

* For the Optical Train only. The PC computer supplies the power for the system components, such as the CCD camera. An external power supply is provided for Laptop computer use.

Physical		
Weight	M^2-200s… 6.8 kg (without camera)	
Measurements		M^2x, M^2y, Kx, Ky, BPPx, BPPy
Statistical results)		Width at waist Wx, Wy
are available on		Divergence angle qx, qy
(all measurements		Waist location Zx, Zy
		Rayleigh X, Y
		Astigmatism
		Asymmetry ratio
Wavelength Range		
Different lenses are needed for different wavelength regions		
The M^2-200s model include 3 standard lenses with nominal 300mm focal lengths. See below		
M^2-200s-FW	266 - 587nm (included)	
	400 - 750nm (included)	
	650 - 1125nm (included)	
	1000 - 1300nm (optional)	
Attenuation Range Nominally from ND 0 to ND 4.8. Actual values vary with wavelength		
Beam Size	0.5mm - 10mm M^2-200s	
	Varies with wavelength, waist size and location, and M^2	
Damage Limits [1]		
Camera	0.15 µW/cm² CW mode for a 10 mm input beam diameter	
	1.0 µJ/cm² pulse mode for a 10 mm input beam diameter	
	Both of the above for an M^2 =1 @ 1064nm	

[1] CCD cameras can be damaged by power in excess of 100 mW/cm² or energy in excess of 100 mJ/cm². The M^2-200s employs a focusing optic. While it may be that the laser input power or energy measures well below this damage threshold, it can easily exceed these levels when focused onto the camera sensor. Use caution and error on the side of safety. CCD cameras can be costly to repair or replace.

Ordering Information

Item	Description	P/N
M^2-200s Beam Propagation Analyzer		
M^2-200s-FW	M^2-200 software, software license, GRAS 20 Firewire camera, short optical train, automatic and manual operation, recommended for 266nm - 1064nm wavelengths	SP90144
M^2-200s-FW-A	M^2-200 software, software license, short optical train, automatic and manual operation, recommended for 266nm - 1064nm wavelengths (GRAS 20 camera not included)	SP90145
M^2-200sM-FW	Manual mode M^2-200 software, software license, GRAS 20 Firewire camera, manual operation with a GRAS 20 Firewire camera (optical train not included)	SP90146
M^2-200sM-FW-A	Manual mode M^2-200 software, software license, manual operation with a Firewire camera (GRAS 20 Firewire camera and optical train not included)	SP90147
1000-1300nm lens	Lens assy telecom, 300mn fl	11402-001

3.6.1.2 Model 1780

Instantly measure M^2

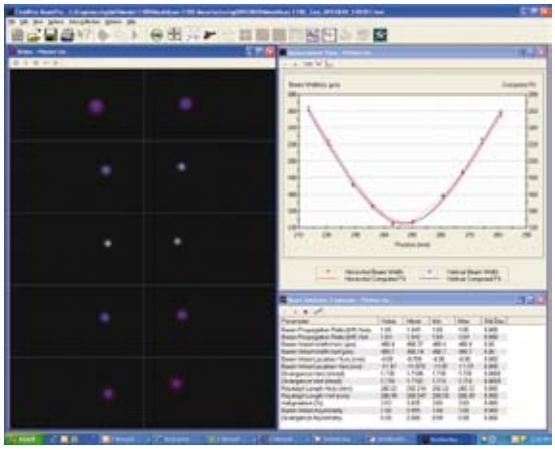
The ModeScan Model 1780 is a laser beam profiling instrument that measures the M^2 Beam Propagation Ratio and all associated ISO 11146 parameters instantaneously in real time at video rates to over 20Hz. The measurement technique, patented by Photon Inc., uses 10 reflective surfaces to form simultaneous images of the propagating beam at 10 locations on a Model 2512 CCD array camera. With all ten measurement positions acquired at once, the instrument is suitable for measurement of both CW and pulsed lasers down to single-shot rates. Beam diameters are obtained with NIST-traceable accuracy to better than 2% using the BeamPro. This translates to M^2 measurements with accuracy to ~5%. The FireWire system operates under Photon's BeamPro in Microsoft Windows. The compactness of the system and the IEEE 1394a FireWire interface offers enhanced ease-of-use and portability. The ability to operate in any orientation allows for easy placement on any optical bench and saves valuable bench space.

The CCD is sensitive from ~250nm to 1100nm wavelengths. The standard configuration is supplied with a glass OD 2.8 C-mount neutral density filter for wavelengths >360nm, and an OD 3.0 Fused Silica Inconel neutral density filter for wavelengths <360nm. Because of the limited usefulness of exposure control with pulsed lasers, the Photon Inc. Model ATP is recommended for use with pulsed lasers with repetition rate <~10kHz and wavelength >360nm. For pulsed lasers with wavelength <360nm, a variable UV filter or a combination of UV filters will generally be required.

ModeScan 1780

ModeScan Model 1780 System Specifications

Optical/Sensor/Detector	
Sensor	Si CCD 1/2" Format
Wavelength	~360nm – ~1100nm (Standard with OD 2.8 filter) ~250nm – ~1100nm with UV optics
Pixel Array	780 (H) × 580 (V)
Pixel Size	8.3µm × 8.3µm
Array Dimension	6.49mm × 4.83mm
Scanning Mode	Progressive
CCD Cover Glass	Removed
Beam Splitters	Fused Silica: <20/10 Scratch Dig, l/10 Flatness
Test Lenses UV: ~250 – 460nm Visible : 425 – 720nm VIS – NIR; 620 – 1080n	200mm fl Fused Silica/250 – 460nm AR coated standard 200mm fl BK7/425 – 720nm AR coated standard 200mm fl BK7/620 – 1080nm AR coated standard other fl's optional for all wavelengths
Fixed Attenuator: Visible – NIR UV	OD 2.8 Absorbing Glass >360nm OD 3.0 Fused Silica Inconel 250 – 450nm
Computer/Electrical	
A / D Conversion	12 Bit
Maximum Frame Rate	35.8fps (full frame @ full resolution)
Exposure range	20µs–27.64ms (Software selectable via 1394 bus)
Gain	0–12dB (Software selectable via 1394 bus)
Trigger	Internal or External (Software selectable)
External Trigger Specifications	5V ±1V @ 10mA ±5mA (Positive transition)
Trigger Connector	10 pin RJ-45 Jack
Trigger Cable	10 pin RJ-45 to BNC 1.8m
Interface	IEEE 1394a (FireWire)
IEEE 1394 Cabl	1.8m
Supply Voltage	+8V – +36V DC (+12V DC nominal), <1% ripple (supplied via IEEE 1394 cable); requires external powered hub with laptop PCs
Supply Power	3.5W max @ 12V DC (typical)
Mechanical	
Filter/Lens Mount	C-mount (1" – 32 tpi)
Mounting	Gimbal Mount on ½" post; 12mm Metric post optional
Dimensions in mm	62 H × 140 W × 210 L , + Gimbal Mount
Weight	~1.4kg
Environmental	
Operating Temperature	O° – +50°C (+32° – 112F)
Humidity	20% – 80%, relative, non-condensing
Conformity	CE; FCC; RoHS and WEEE



Arrangement of Measurement Windows: Video Window Beam Propagation Mode; Beam Statistics Window; Horizontal and Vertical Caustics Window.

Ordering Information

Item	Description	P/N
ModeScan 1780 M^2 System with Fire Wire BeamPro		
MS-1780	ModeScan Model 1780, dedicated M^2 measurement system, with 12-bit FireWire (IEEE 1394a) CCD detector for single-shot, pulsed and CW lasers. System includes: ModeScan with gimbaled mount for alignment; FireWire CCD camera; Photon FireWire BeamPro Acquisition and Analysis Software stand-alone GUI with M^2 Analysis; Active X automation interface; 200mm lens coated for Visible range (400–700nm); OD 2.8 glass filter for operation >360nm; Dimensions: 62mm x 140mm x 210mm; For use from 250–1100nm wavelengths - UV and NIR operation will require additional specifically coated optics.	PH00096
MS 1780 Lens Kits	All lens kits contain 200mm, 250mm, 400mm, 500mm, 750mm and 1m focal length coated lens with mounting hardware and MS-Tube Kit.	
MS-NIR Kit	Set of lenses coated for operation in NIR (700–1100nm)	PH00111
MS-VIS Kit	Set of lenses coated for operation in VIS (400–700nm)	PH00104
MS-UV Kit	Set of lenses coated for operation in UV (250–400nm)	PH00097
MS-YAG Kit	Set of all the available lenses for all wavelengths (MS-NIR,VIS and UV Kits combined) and MS-Tube Kit	PH00118
MS-TUBE Kit	Set of C-Mount tubes to mount lenses to the MS-1780. Includes 100mm, 50mm, 40mm, 25mm, 10mm and 50-90mm adjustable focusing tube	PH00127
ModeScan 1780 Accessories		
UV Lens Kit (MS-UV kit)	UV lenses are all fused silica plano-convex and coated for UV wavelengths 250-400nm	PH00097
UV200	200mm focal length lens	PH00098
UV250	250mm focal length lens	PH00099
UV350	350mm focal length lens	PH00100
UV500	500mm focal length lens	PH00101
UV750	750mm focal length lens	PH00102
UV1000	1000mm focal length lens	PH00103
MS-VIS Lens Kit (MS-VIS kit)	Visible (VIS) lenses are all BK 7 plano-convex and coated for visible wavelengths 450–650nm	PH00104
VIS200	200mm focal length lens	PH00105
VIS250	250mm focal length lens	PH00106
VIS400	400mm focal length lens	PH00107
VIS500	500mm focal length lens	PH00108
VIS750	750mm focal length lens	PH00109
VIS1000	1000mm focal length lens	PH00110
MS-NIR Lens Kit (MS-NIR kit)	NIR lenses are all BK-7 Plano-convex and coated for NIR wavelengths 700-1100nm	PH00111
NIR200	200mm focal length lens	PH00112
NIR250	250mm focal length lens	PH00113
NIR400	400mm focal length lens	PH00114
NIR500	500mm focal length lens	PH00115
NIR750	750mm focal length lens	PH00116
NIR1000	1000mm focal length lens	PH00117
Extension and Focusing Tubes		
CM-EXT100	100mm long C-Mount extension tube for mounting lenses outside ModeScan 1780 Box	PH00119
CM-EXT50	50mm long C-Mount extension tube for mounting lenses outside ModeScan 1780 Box	PH00120
CM-EXT40	40mm long C-Mount extension tube for mounting lenses outside ModeScan 1780 Box	PH00121
CM-EXT25	25mm long C-Mount extension tube for mounting lenses outside ModeScan 1780 Box	PH00122
CM-EXT10	10mm long C-Mount extension tube for mounting lenses outside ModeScan 1780 Box	PH00123
FOCTUBE20-30	C-Mount fine thread focus tube with 20–30mm adjustable length for focus of lenses mounted to extension tubes	PH00124
FOCTUBE30-50	C-Mount fine thread focus tube with 30–50mm adjustable length for focus of lenses mounted to extension tubes	PH00125
FOCTUBE50-90	C-Mount fine thread focus tube with 50–90mm adjustable length for focus of lenses mounted to extension tubes	PH00126
MS-TUBE Kit	Tube Kit for MS-1780	PH00127

3.6.2 Slit - Based Beam Propagation Analyzer M^2

NanoModeScan

The NanoModeScan combines the flexibility and speed of the NanoScan with dedicated M^2 measurement hardware and software. The NanoModeScan provides an automated measurement of M^2 using either the ISO 11146 or the Rayleigh method.

The ISO Method software and hardware report the ISO 11146 parameters:

- Times diffraction limit: M^2
- Beam propagation factor: K
- Beam waist size: d_0
- Beam waist location: Z_0
- Divergence: θ
- Rayleigh range: Z_r

NanoModeScan

By adding the capabilities of the NanoScan to the ModeScan, the range of possible measurable lasers is greatly expanded and the speed of the measurements dramatically improved. The NanoScan's software controlled variable scan speed allows the measurement of both CW and kHz pulsed lasers with any NanoScan scan head, covering the entire wavelength range from UV to FIR. The NanoScan's rapid beam finding and autoranging speed up the total M^2 measurement to ~20 seconds for CW lasers. Both 200mm and 400mm lenses are available to generate the proper artificial waist for the laser source under test. For ease of alignment, there is an entrance iris on the optical axis of the NanoModeScan and a precision alignment stage for horizontal and vertical positioning.

The ISO 11146 Method

The ISO 11146 method for measuring the propagation of a laser source calls for the measurement of the beam diameter for at least 10 positions through the waist created by a test lens inserted in the beam path. Five locations should be within ±1 Rayleigh range of the artificial waist and at least five more points beyond two Rayleigh ranges from this waist. These measurements are then used to compute the laser propagation parameters. Once points are selected properly, the ISO Method is the fastest measurement method and best for volume testing of lasers.

The Rayleigh Method

The ISO method requires the user to manually select the measurement points, and changing one or two of the selected points can yield different M^2 values. The Rayleigh method is completely automated, selecting its own measurement points based on mapping the Rayleigh range of the beam waist. This method is fully discussed in Application Note 230, *Fast M^2(k-factor) Measures with Photon Beam Profilers*. In addition, the Rayleigh method can yield more consistent results for M^2 values for lasers that are not exactly like those for which the ISO standard was written, such as fiber lasers, lensed diode lasers, and VCSELs.

The NanoScan Difference

With the NanoScan-equipped NanoModeScan, all scan heads can measure pulsed beams with repetition frequencies down to 10kHz. Measuring pulsed beams in discussed in the application note *Measuring Pulsed Beams with a Slit-Based Profiler*. The silicon and germanium detectors will measure less than a milliwatt of power. The pyroelectric detector-equipped NanoScan head can analyze higher power lasers at all wavelengths. The increased dynamic range of the NanoScan enhances the signal to noise ratio of the system and allows a much broader range of laser powers to be analyzed with one instrument setup.

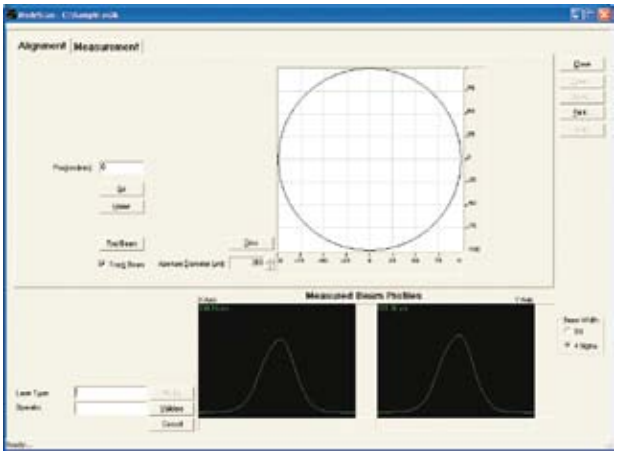
Real-Time Divergence Measurement

By monitoring the divergence angle θ, it is possible to make a measurement that will be directly proportional to M^2. This enables the adjustment of the laser performance in real time at the NanoScan's rapid update rate (up to 20Hz). To use this feature, the scan head is moved to a position one geometric focal length from the test lens. Divergence is the beam diameter divided by the focal length, and the measured divergence is equal to M times the embedded divergence.

Therefore when the beam diameter at this location is minimized, the divergence is at its minimum and the M^2 of the laser should then be optimized. After this real-time adjustment, the full M^2 measurement can be done to generate the required parameter values. This method makes the NanoModeScan an even more valuable tool for the final setup of lasers on the manufacturing floor by decreasing the time it takes both to adjust the laser system and to make the measurements required for quality control documentation.

NanoModeScan Specifications

Sensor/Detector	
Scan head Travel	500mm
Optical Axis Height	140-170mm
Standard Lenses	200mm EFL, BK-7 plano-convex, Broadband AR Coated 400mm EFL, BK-7 plano-convex, Broadband AR Coated; UV through long IR lenses available
Optional Lens	200mm FL fused silica for UV coated for wavelength of use 350mm FL fused silica for UV coated for wavelength of use 190mm FL IR lens for 10.6µm wavelength
Minimum Spot Size	See scan head specifications
Computer/Electrical	
Source Power	See scan head specifications
File Saving and Data Logging	Data files, ASCII Files
AC Power	110V, 60Hz standard 220V, 50Hz optional
Communication	RS-232 Interface or USB to RS-232 adapter required
Mechanical (Dimensions in mm)	
NanoModeScan Linear Stage	812 × 102 × 78
Photon Motion Controller	273 × 89 × 57
Removable Light Shield	787 × 777 × 110
Weight	
NanoModeScan Linear Stage	8.4kg
Photon Motion Controller	1.5kg



Alignment screen in ModeScan software

Measurement results screen in ModeScan software

Ordering Information - NanoModeScan M^2 Systems

All NanoModeScan Systems include (unless otherwise noted):

- High-resolution scanhead with rotation mount.
- Two BK 7 lenses and mounts. Standard are 200 and 400mm focal length.
- Lens coating Choices:
  - VIS Visible: 430–700nm (not for use with Germanium detector)
  - NIR Near IR: 650–1000nm
  - LIR Long IR: 1000–1550nm (not for use with Silicon detector)
- VLIR: Very long infrared >1550nm. The two glass lenses will not be included but instead credited toward the very long wavelength IR lens or lenses that will require an optional charge (for use with MSP-NS-Pyro/9/5 only).
- OPTIONAL UV: If ultraviolet application, the two glass lenses will not be included; instead we will send one 200 mm focal length lens coated for wavelength of use.

Be sure to specify XXX wavelength when ordering.

Item	Description	P/N
NanoModeScan M^2 Systems		
USB MSP-NS-Si/9/5	Model 1740 ModeScan with NanoScan Silicon (Si) Detector 9mm aperture 5µm slits Si detector, 63.5mm diameter head, 9mm entrance aperture, and matched pair of 5.0µm wide slits. Use from 190 to 1000nm wavelengths.	PH00233
USB MSP-NS-Ge/9/5	Model 1740 ModeScan with NanoScan Germanium (GE) Detector 9mm aperture 5.0µm slits. Germanium detector, 63.5mm diameter head, 9mm entrance aperture, and matched pair of 5.0µm wide slits. Use from 700nm to 1.8µm wavelength.	PH00234
USB MSP-NS-Pyro/9/5	Model 1740 ModeScan with NanoScan Pyroelectric Detector 9.0mm aperture 5µm slits. Pyroelectric detector, 63.5mm diameter head, 9mm entrance aperture, and matched pair of 5µm wide slits.	PH00235
MSP-NS-Pyro/20/25	Model 1740 ModeScan with large aperture NanoScan scanhead with 20mm Pyroelectric Detector, 25um slits 100mm diameter head, 20mm entrance aperture and matched pair of 25um wide slits.	PH00218
USB MSP-HPNS/10/5	Model 1740 ModeScan with HP NanoScan scanhead with 9mm Pyroelectric Detector 5µm slits,100mm diameter head, 9 mm entrance aperture, and matched pair of 5µm wide slits; scanhead is fancooled.	PH00236
NanoModeScan Accessories		
LENS 200 UV-XXX	Optional 200mm quartz lens for use between 190–400nm wavelengths.	PH00090
LENS 400 UV-XXX	Optional 400mm quartz lens for use between 190–400nm wavelengths.	PH00091
LENS 190 10.6	Optional 7.5-inch focal length lens for use at 10.6µm wavelength.	PH00092
LENS 100 VIS	Optional 100 mm focal length lens for use 400–700nm wavelength.	PH00093
LENS 100 NIR	Optional 100 mm focal length lens for use 650–1000 nm wavelength.	PH00094
LENS 100 LIR	Optional 100 mm focal length lens for use 1000–1550nm wavelength.	PH00095
1740 LENS MNT	Lens mount for users wanting to use their own 25mm diameter lens.	PH00075
CUSTOM LENS	Specify wavelength, focal length	PH00088
Model 1740	ModeScan Rail w/o scan head	PH00074
1740 LENS PREP	ModeScan custom lens	PH00076
1740 TRNG	ModeScan onsite operation training	PH00077
Lens 400 2um	Optional 400mm focal length lens for use at @2µm wavelength	PH00224
Lens 200mm VIS	Optional 200mm focal length lens for use 400-700nm wavelength	PH00237
Lens 400mm VIS	Optional 400mm focal length lens for use 400-700nm wavelength	PH00238
Lens 200mm NIR	Optional 200mm focal length lens for use 650-1000nm wavelength	PH00239
Lens 400mm NIR	Optional 400mm focal length lens for use at 650-1000nm wavelength	PH00240
Lens 200mm LIR	Optional 200mm focal length lens for use at 1000-1550nm wavelength	PH00241
lens 400mm LIR	Optional 400mm focal length lens for use at 1000-1550nm wavelength	PH00242

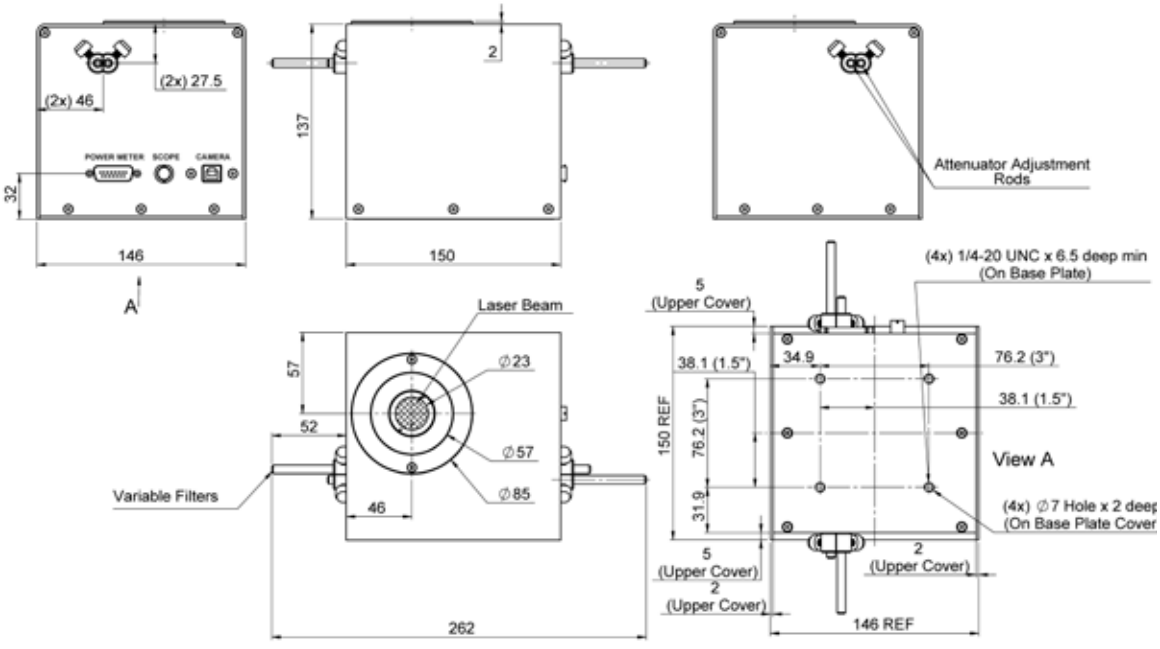
3.7 Integrated Laser Performance Measurements

3.7.1 Beam Cube - Beam Profiling/Power/Focus Spot Position/Temporal Pulse Shape

Features

- Monitor all important beam parameters to keep tight control over process
- Beam Cube measures beam profile, focal spot position, temporal pulse shape and power, up to 150W
- Portable - can be moved from laser to laser to monitor all lasers in plant
- For measuring at or near focal spot

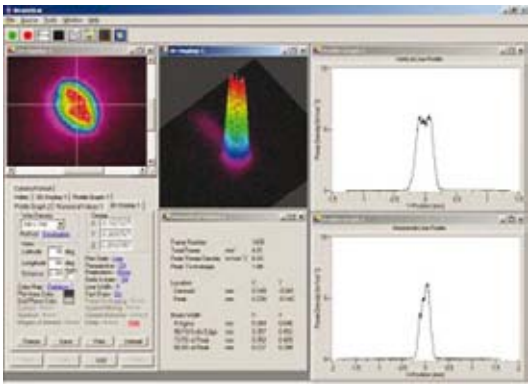
Beam Cube



An integrated laser beam measurement/profiler system for pulsed and CW lasers. System contains an SP620 camera with variable attenuator for beam profiling. A thermopile power head for power measurement and a high speed photodiode for temporal pulse width measurement. Includes BeamGage Standard beam profiling software, and a USBI power meter w/StarLab software. An optional USB digital oscilloscope is available for temporal measurement of pulsed lasers, order p/n SPE10008. Or a standard laboratory oscilloscope can be used.

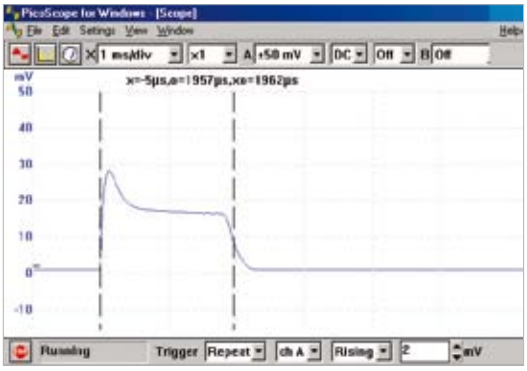
Diagnostic Capabilities: Spatial Beam Profile

The Beam Cube shows you the intensity profile of your beam in real time and allows you to adjust your laser resonator and beam delivery optical system for optimum beam quality on line. You can also measure the cross section at any point as shown. The illustration shows the intensity distribution of a pulsed Nd:YAG laser where the X and Y profiles are taken at the cursor lines which can be placed anywhere on the beam. This data can be saved, brought back and manipulated at any time so you can compare the present profile with a reference. The system has an exclusive optical design making it easy for you to adjust the intensity to get the optimum picture by just pushing and pulling the attenuating filter adjustment levers. The beam profile can also be shown in a three-dimensional form which can be rotated to different angles and elevations.



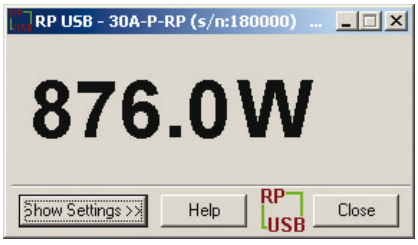
Temporal Pulse Shape

The temporal profile of laser pulses, important in obtaining consistent process results, can now be easily monitored. Shown to the right is the pulse shape of the same pulsed Nd:YAG laser with 2ms pulses. It is being measured with a PC oscilloscope available as an accessory. You can display the pulse shape alone or together with the beam profile on your PC. Plug the Beam Cube output into an oscilloscope to observe the temporal pulse shape of your laser beam.



Average Laser Power

With the Ophir USB Interface between the Beam Cube unit and your PC or laptop, you can measure the average power of your laser to an accuracy of ± 3%.

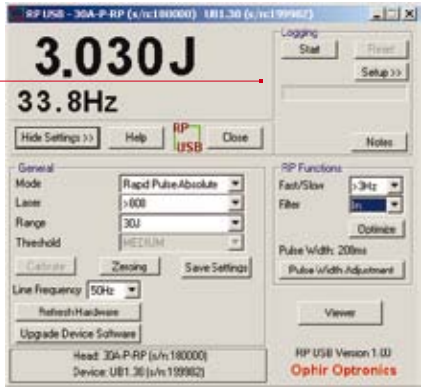


Energy per Pulse and Frequency

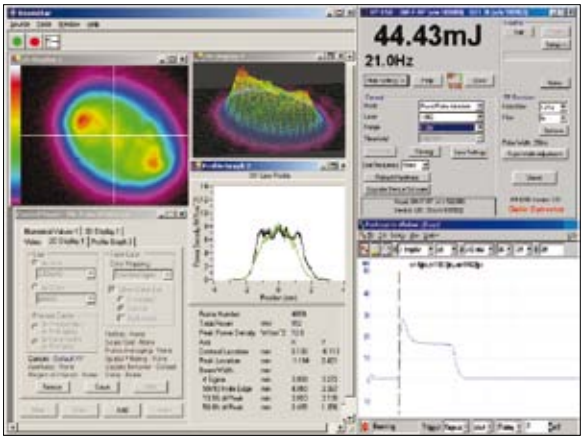
Energy sensor inside the Beam Cube is able to measure the energy per pulse and the frequency of the laser to high accuracy. With the USB Interface you can display this on your PC or laptop screen.

Statistics

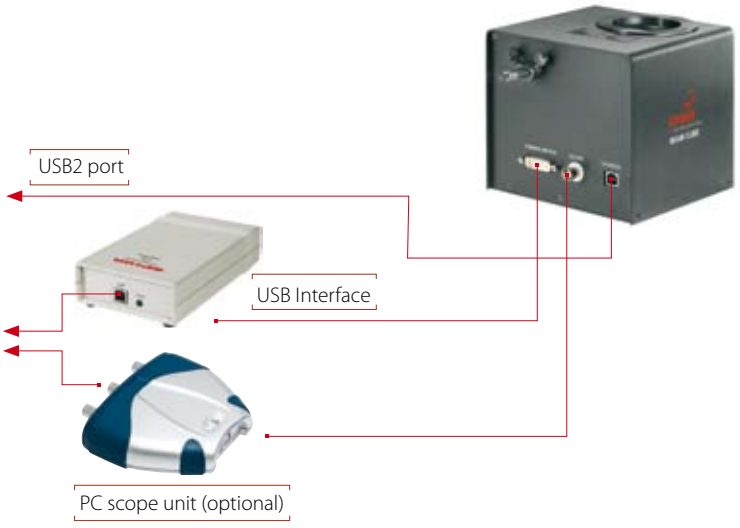
The Beam Cube with USB Interface is able to record and store an unlimited number of points in your PC. The software provided has a number of ways of displaying the statistics of the data.



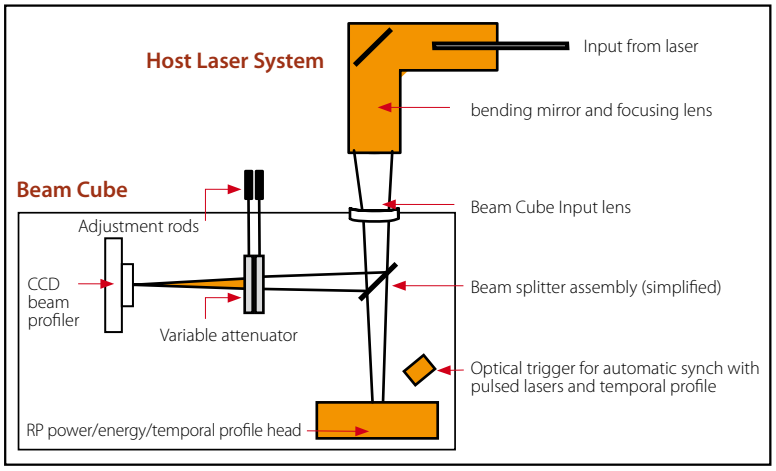
Schematic setup of a Beam Cube system



Laptop or desktop PC screen showing spatial beam profile, temporal profile, power, energy and frequency



Simplified Schematic of Beam Cube System



Specifications

General		Beam Cube
Max and min average power		1W to 100W continuous and to 150W for up to 1 min
Maximum average power density [a], [c]		4kW/cm² at entrance window
Max and min energy		20mJ [b] to 100Joules
Maximum energy density and repetition rate at entrance window vs. pulse width	pulse width	max energy density
	10ms	20J/cm²
	2ms	5J/cm²
	0.5ms	1.5J/cm²
Cooling System		Conduction cooled
Dimensions		22cm L x 16cm W x 14cm H
Spectral Range		400 - 1100nm (calibrated for 1064nm)
Beam profiler unit		
Camera		SP620U 1600x1200 pixel camera with 4.4µm spacing
PC interface		USB2
Shutter speeds		Continuously variable 1/frame rate to 1/6,000, manual or automatic
Gain control		0dB to 27dB in ~700 steps (each step is ~0.035dB). Manual or automatic control
Frame rate at 640x480 pixel ROI		Std Beam Cube: 60Hz. Auto synch with laser Beam Cube 620: 20Hz. Auto synch with laser
Software features		Automatic gain and shutter control. Peak and Centroid position tracking. 2D and 3D contour map. Sophisticated noise and background control. Best fit to gaussian or top hat profile 3D display viewable from any angle or elevation. Store and recall screens in single or video fashion. 3 different measures of beam width, of peak, 4 sigma and 90/10 knife edge. Save numerical data files of profiles. Log data with time. Full on line instructions and help. Fully flexible screen format.
Minimum PC system requirements		Pentium-4 2GHz, 256 MB Memory, Operating system, Windows XP Service Pack 2 or Vista 32.
Intensity adjustment		Continuously variable filters actuated from outside the unit.
System optical performance		
Field of view		±6°
Maximum beam size		Ø22mm at entrance for converging beam, Ø7mm for collimated beams
Beam reduction or expansion		Expanded 2-3X . With no lens 1X
Resolution		~5µm
Power / energy / temporal profile unit		
Temporal pulse shape response time into oscilloscope		200µs resp. time. Maximum peak power 1000W.
Software functions with USB Interface connected to PC or laptop		average power, statistics
Data logging		Can send unlimited number of points in real time to PC via USB Interface at >1000 point/s. Windows software provided for data analysis.

Notes: (a) The power density limitation applies to any surface that the beam hits. For Beam Cube, since the object plane is outside the instrument, focal spots of much higher power density can be imaged as long as the power density limit on the optical surfaces is not exceeded.
Notes: (b) The Beam Cube will not resolve pulses of energy below 20mJ unless the pulse rate is high. If the energy deposited in 1/50th of a second exceeds 20mJ, then the unit will be able to show the pulses even though the individual energies are below 20mJ.
Notes: (c) If the beam power or energy density on the entrance window exceeds specifications, the window can be removed and not used, assuming that the power and energy density on the first beam splitter is below the damage threshold.

Ordering Information

Item	Description	Ophir P/N
Beam Cube 620	BeamCube system for beam profiling and power and energy. Optional PC oscilloscope for measuring pulse change for pulsed lasers. Comes with 100mm lens assembly. Uses SP620 beam profiling camera.	SP90323
-50mm lens assembly	Optional -50mm lens assembly for Beam Cube	SPZ08255
Optional PC oscilloscope	1MHz virtual oscilloscope for Beam Cube or BA500 to turn your PC into an oscilloscope displaying the temporal pulse shape. Uses PC or laptop USB port	SPE10008

3.8 High-Power Applications

3.8.1 High-Power NanoScan

Photon's High-Power NanoScan can measure focused CO_2 laser beams up to 5 kilowatts. The High-Power NanoScan is equipped with a pyroelectric detector with copper slits and drum. A cooling fan mounted on the scan head body provides additional heat management. With the new "peak connect" algorithm and the software controlled variable scan speed, the High-Power NanoScan is ideal for measuring lasers operating with pulse width modulation (PWM) power control. Measurement of Q-switched lasers and other higher frequency pulsed lasers is also possible using this feature.

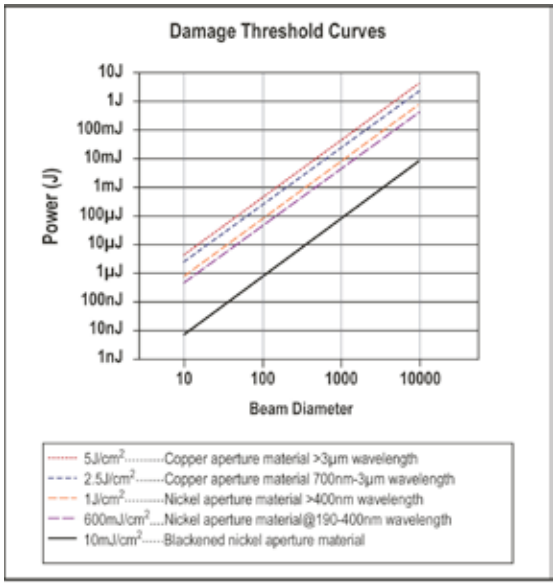
What Can be Measured?

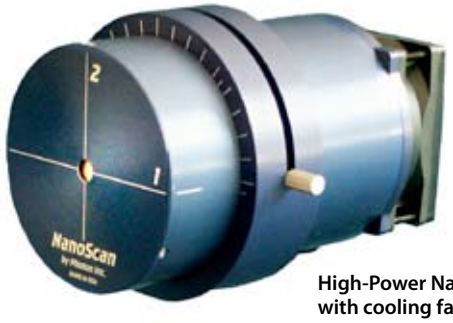
Measuring high-power beams can be tricky. The lasers have the potential to damage the scan head, and any reflected light can be dangerous to both the operator and the surroundings. The High-Power NanoScan can measure these beams because it uses a combination of highly reflective components with high thermal dissipation capability. It is important to manage the reflected beam so that it neither reenters the laser cavity nor sends stray beams into the surrounding area. The scan head is designed to make short duration measurements to avoid excessive heating of components. The head should be only in the incident beam for 10 to 60 seconds depending on the power levels to prevent excessive heating of the components. The High-Power NanoScan scan head has been shown to be able to handle power densities of 3.2MWcm^{-2} at 10.6µm, the power density of a 200µm beam at 1kW. At the shorter wavelengths of the other common industrial lasers, Nd:YAG and DPSS, the upper limits are a little less, due to the slightly lower reflectivity of the components at wavelengths around 1000nm. Visible and UV lasers can also be measured, but these will have lower limits yet.

The chart below shows the damage thresholds for pulsed beam energies for the three wavelength regimes. The lines represent the maximum energies per pulse for various spot sizes that correspond to 5J/cm^2 for the 3µm to 100µm wavelengths, 2.5J/cm^2 for the 700nm to 3µm range, and 250mJ/cm^2 for the UV-Visible range from 190nm to 700nm. When operating with pulsed lasers, calculate the energy per pulse to ensure that the values fall below these lines for the wavelength of the laser. Operation above these values will likely cause damage to the scan head apertures.

Minimum Beam Size per Pulse Frequency

NanoScan	Large Drum (HP)			
Rotation Rate (Hz)	1.25	2.50	5.00	10.00
Slit Speed (µm/msec)	233.25	466.50	933.01	1866.01
Data Points per Profile	15	15	15	15
Pulse Frequency (kHz)	Minimum Beam Diameter in µm			
0.5	6998	13995	N/A	N/A
1	3499	6998	13995	N/A
2	1749	3499	6998	13995
3	1166	2333	4665	9330
4	875	1749	3499	6998
5	700	1400	2799	5598
6	583	1166	2333	4665
7	500	1000	1999	3999
8	437	875	1749	3499
9	389	778	1555	3110
10	350	700	1400	2799
11	318	636	1272	2545
12	292	583	1166	2333
13	269	538	1077	2153
14	250	500	1000	1999
15	233	467	933	1866
16	219	437	875	1749
17	206	412	823	1646
18	194	389	778	1555
19	184	368	737	1473
20	175	350	700	1400
21	167	333	666	1333
22	159	318	636	1272
23	152	304	608	1217
24	146	292	583	1166
25	140	280	560	1120
50	70	140	280	560
100	35	70	140	280
150	23	47	93	187





High-Power NanoScan with cooling fan

High-Power NanoScan Configurations

Detector Type	Power Range	Wavelength	Aperture	Slits	Scan Head Size
Pyroelectric	~1W - ~5W upper limit dependent on wevelength	190nm - > 100µm	9mm	5µm	100mm
Pyroelectric Large Aperture	~1W - ~5W upper limit dependent on wevelength	190nm - > 100µm	20mm	10µm	100mm

High-Power NanoScan

Ordering Information - High-Power NanoScan

All High-Power NanoScan Systems Include: Fan cooled scanhead. For use at wavelengths from 200nm to greater than 20µm. Maximum power capacity is dependent on wavelength and spot size. Refer to operating space charts for more information.
Slits and scan drum are highly reflective and user must send reflected energy into appropriate dump. A direct back reflection may cause laser cavity to oscillate or if not properly directed may cause damage. User must handle all back-reflected energy from laser.
NanoScan Integrated Software package. Software for use with NanoScan under Microsoft Windows (32 Bit version only) 2000 Professional, XP Professional, Vista and windows 7 (32/64) operating systems.
Measurements include: spot size, position and position difference information and laser profiles. Includes "peak connect" and software control of scan speed for measurement of pulsed and pulse width modulated (PWM). Software includes ability to capture and record bursts of data and ActiveX automation.
USB 2.0 controller replaces the PCI bus card and allows NanoScan to interface to USB 2.0 port of laptop or desktop PC. Performance of Certificate of Calibration traceable to National Institute of Standards and Testing (NIST) to better than ±3%.

Pyroelectric Detectors

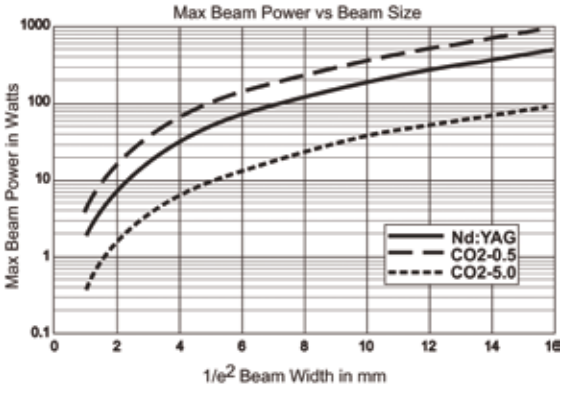
Item	Description	P/N
USB NS-PYRO/9/5	NanoScan Pyroelectric Detector 9mm aperture 5micron slits. High-resolution head featuring pyroelectric detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5µm wide slits. Use for wavelengths from 190nm to >20µm. This model does not include a cooling fan USB	PH00025
USB NS-PYRO/9/25	NanoScan Pyroelectric Detector 9mm aperture 25micron slits. High-resolution head featuring pyroelectric detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 25µm wide slits. Use for wavelengths from 190nm to >20µm. This model does not include a cooling fan.	PH00228
USB NS-PYRO/20/25	NanoScan Large Area Pyroelectric Detector 20mm aperture 25micron slits. High-resolution head featuring pyroelectric detector, 100mm diameter head with rotation mount, 20mm entrance aperture, and matched pair of 25micron wide slits. Use for wavelengths from 190nm to >20micron. This model does not include a cooling fan. USB	PH00026
USB NS-PYRO HP/20/10	High-Power NanoScan scanhead with 20mm Pyroelectric Detector 10µm slits for use with higher power beams. High-resolution profiler featuring pyroelectric detector, 100mm diameter scanhead with rotation mount, 20 mm entrance aperture, and matched pair of 10-µm wide slits. Can measure spots 50 µm and larger ($1/e^2$ diameter) directly. Works with CW and pulsed beams with rates greater than 2kHz. Actual minimum pulse rate is dependent on beam size and scan rate. USB	PH00027
USB NS-PYRO HP/9/5	High-Power NanoScan scanhead with 9mm Pyroelectric Detector 5µm slits for use with higher power beams. High-resolution profiler featuring pyroelectric detector, 100mm diameter scanhead with rotation mount and matched pair of 5-µm wide slits. Use to measure spots 20µm and larger (1/e2 diameter) directly. Works with CW and pulsed beams with rates greater than 2kHz. Actual minimum pulse rate is dependent on beam size and scan rate. USB	PH00028
NH-PYRO/9/5	Head only NanoScan-Pyro 9mm aperture 5µm slits	PH00041
NH-PYRO/9/25	Head only NanoScan-Pyro 9mm aperture 25µm slits	PH00243
NH-PYRO/20/25	Head only NanoScan-Pyro 20mm aperture 25µm slits	PH00042
NH-HP-NS/20/10	Head only High-Power NanoScan 20mm aperture 10µm slits	PH00043
NH-HP-NS/9/5	Head only High-Power NanoScan 9mm aperture 5µm slits	PH00044

3.8.2 High Power - Laser Profiler Kits for Nd:YAG

- A portable solution for medium power lasers
- Up to 500W Nd:YAG
- Up to 31mm beam widths (16mm $1/e^2$ width)
- Easy operation - level, set and shoot
- Optimize beams in real-time
- Diagnose problems quickly

The LPK-YAG Beam Profiler Kit consist of an A/R coated reflecting wedge, ND filters, beam telescope to reduce larger beams, a CCD camera, and BeamGage software. The kit is designed to be conveniently placed in a horizontal beam, or under a down directed beam, to measure raw beam characteristics & stability. The user must safely handle the 90 to 98% of the beam that passes through the wedge. A PC style computer is required but not included. See the BeamGage section for software features and calculations. See the camera section for specifications.

LPK-YAG-16



Model	Beam Reduction	Beam Sizes	Wavelength	Type of Attenuator	Camera
LPK-YAG-2.5-FW, LPK-YAG-2.5-USB	1X	0.1 - 2.5mm	1064nm	1% beam splitter + assorted attenuators	Si CCD
LPK-YAG-7-FW, LPK-YAG-7-USB	3X	1.0 - 7.0mm	1064nm	1% beam splitter + assorted attenuators	Si CCD
LPK-YAG-16-FW, LPK-YAG-16-USB	10X	3.0 - 16mm	1064nm	1% beam splitter + assorted attenuators	Si CCD
PK-YAG-16-18200	10X	3.0 - 16mm	1064nm	1% beam splitter + assorted attenuators	Si CCD

Ordering Information

Item	Description	P/N
LPK-YAG-2.5-USB	BeamGage software, SP620U camera, LBS-100-YAG beam splitter/attenuator, base plate, miscellaneous hardware. Suitable for beams 0.1 to 2.5mm.*	SP90168
LPK-YAG-7-USB	BeamGage software, SP620U camera, LBS-100-YAG beam splitter/attenuator, 3X telescope, base plate, miscellaneous hardware. Suitable for beams 1.0 to 7mm.*	SP90169
LPK-YAG-16-USB	BeamGage software, SP620U camera, LBS-100-YAG beam splitter/attenuator, 10X telescope, base plate, miscellaneous hardware. Suitable for beams 3.0 to 16mm.*	SP90170
LPK-YAG-16-18200	BeamGage software, Gige 18200 camera bundled with BeamGage Enterprise , LBS-100-YAG beam splitter/ attenuator, 10X telescope, base plate, miscellaneous hardware. Suitable for beams 3.0 to 16mm.*	SP90328

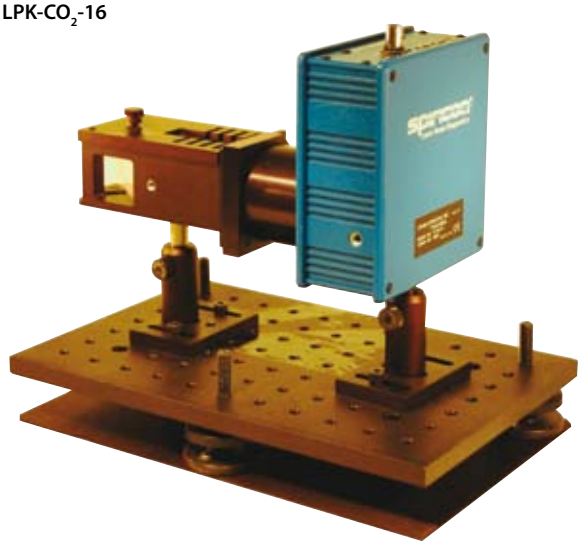
* Maximum beam size assumes zero diffraction from the wings of the beam. Beams of up to 1.5X the maximum size can be applied with minimal diffraction. Beams of up to 2X the above size can be applied, but noticeable diffraction will occur.

3.8.3 High Power - Laser Profiler Kits for CO_2

- A portable solution for medium power lasers
- Up to 1000W CO_2
- Up to 31mm beam widths (16mm $1/e^2$ width)
- Level, set and shoot - Easy operation

The LPK-CO_2 Beam Profiler Kits consist of an A/R coated reflecting wedge, CaF_2 filters, beam telescope to reduce larger beams, Firewire Pyrocam camera, BeamGage software computer and interface card if required. The kit is designed to be conveniently placed in a horizontal beam, or under a down directed beam, to measure raw beam characteristics & stability. The user must safely handle the 95 to 99.5% of the beam that passes through the wedge. A PC style computer is required but not included. See the BeamGage Software section for software features and calculations. See the table below for specifications.

LPK-CO_2-16



Model	Beam Reduction	Beam Sizes	Wavelength	Type of Attenuator	Camera
LPK-CO_2-6.4-0.5	1X	1.0 - 6.4mm	10.6µm	0.5% beam splitter + assorted attenuators	Pyrocam III
LPK-CO_2-6.4-5.0	1X	1.0 - 6.4mm	10.6µm	5% beam splitter + assorted attenuators	Pyrocam III
LPK-CO_2-16-0.5	3X	3.0 - 16mm	10.6µm	0.5% beam splitter + assorted attenuators	Pyrocam III
LPK-CO_2-16-5.0	3X	3.0 - 16mm	10.6µm	5% beam splitter + assorted attenuators	Pyrocam III

Ordering Information

Item	Description	P/N
LPK-CO_2-6.4-0.5	BGS-PC-PIII software, Pyrocam III with chopper (PY-III-C-B-10.6), LBS-100-IR-0.5 beam splitter/attenuator, base plate, miscellaneous hardware. Suitable for beams 1.0 to 6.4mm.*	SP90075
LPK-CO_2-6.4-5.0	BGS-PC-PIII software, Pyrocam III with chopper (PY-III-C-B-10.6), LBS-100-IR-5.0 beam splitter/attenuator, base plate, miscellaneous hardware. Suitable for beams 1.0 to 6.4mm.*	SP90076
LPK-CO_2-16-0.5	BGS-PC-PIII software, Pyrocam III with chopper (PY-III-C-B-10.6), LBS-100-IR-0.5 beam splitter/attenuator, 3X telescope, base plate, miscellaneous hardware. Suitable for beams 3.0 to 16mm.*	SP90077
LPK-CO_2-16-5.0	BGS-PC-PIII software, Pyrocam III with chopper (PY-III-C-B-10.6), LBS-100-IR-5.0 beam splitter/attenuator, 3X telescope, base plate, miscellaneous hardware. Suitable for beams 3.0 to 16mm.*	SP90078

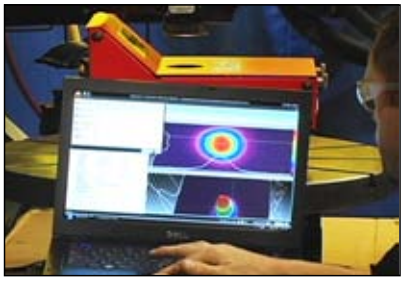
* Maximum beam size assumes zero diffraction from the wings of the beam. Beams of up to 1.5X the maximum size can be applied with minimal diffraction. Beams of up to 2X the above size can be applied, but noticeable diffraction will occur.

3.8.4 High Power - ModeCheck® - A New Method to Assure the Performance of High Power CO_2 Lasers

- Beam Profiler for collimated 50W-500KW, 10.6um wavelength, beam width up to 30mm.
- Quality Cutting, Marking, Drilling & Ablating Require More Than Consistent Laser Power
- Instantaneously "see" and measure the beam - reduce set-up time between jobs
- Real-time "mode burns" - eliminate hazardous acrylic vapors
- Optimize laser efficiency - reduce cost per part
- Predict laser preventative maintenance - increase manufacturing efficiency

ModeCheck is designed for the industrial parts manufacturer to reduce the time it takes to change over between different jobs. The user can quickly place the ModeCheck in front of the laser and see and measure, in real-time, the laser beam profile to confirm optimal laser performance. In addition, and when used periodically, the user can compare measurement changes from the same set-up and make necessary laser adjustments, keeping the laser output constant for the same job from day-to-day. Over time the user will be able to see and measure laser degradation to predict and advance schedule down-time needed for periodic maintenance.

ModeCheck eliminates operator exposure to acrylic mode burn hazards while improving product quality and manufacturing efficiency.



Measurements:

In addition to both 2D and 3D graphical image display and save, the following measurements are made from each image:

- Beam Widths and Diameters
- Beam Position Stability
- Power Density Peak
- Beam Centroid Location
- Elliptical Analysis with Major Axis Orientation

It's just this easy.

1. Remove Focusing optic
2. Locate the beam center with pointing beam or similar device
3. Place ModeCheck in beam center
4. Turn on Laser
5. Instantly see, measure and electronically store the beam characteristics

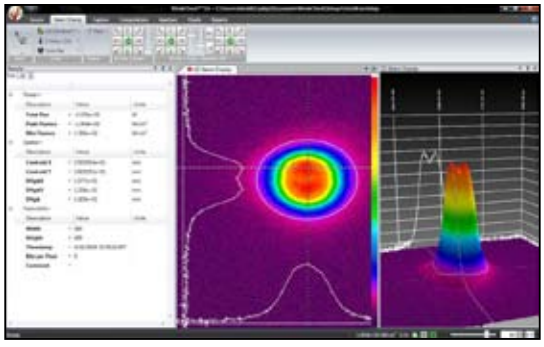
Optional Accessories

One must manage the pass-through laser beam by collecting the beam using either a power meter or beam dump. We recommend using a power meter as the additional measurement information will assist in managing laser optimization. Note that any beam dump or power meter large enough to handle 5kW will require water cooling. There are holes on the bottom of ModeCheck for mounting the Power Meter Head or Beam Dump.

A ruggedized storage/carrying case is highly recommended for safe and efficient handling.

The ModeCheck Lens Adapter (MLA) is an option that will enable a ModeCheck to recollimate a focused CO2 laser beam. The advantage of using this adapter is that the focusing head of the machine does not have to be removed, which is the normal case for a ModeCheck without this adapter. The disadvantage is that the ModeCheck must be positioned further from the output head in order to properly recreate the collimated beam profile. The re-collimating lens must be supplied by the user and must be the same lens that is used on the lasers cutting head. (See application note: SP90329).

A PC is required to run the ModeCheck imaging software. The camera is powered over the USB cable that connects the computer to ModeCheck.



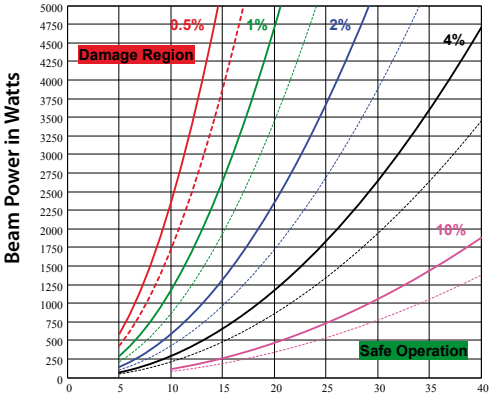
ModeCheck makes instantaneous beam measurements along with graphically displaying both the 2D and 3D power density distribution

Specifications

Model	ModeCheck
Laser Input Power	50-5000 Watts
Input Clear Aperture	50mm (~2")
Beam Width	5mm - 30mm
Pick-off Percent	0.5%, 1%, 2%, 4%, 10% sampling wands; user replaceable
Damage Threshold	27 - 36 W/cm^2; See graph
Camera	1/3" format CMOS, 640x480, 6µm pixel, 8bit, CS-mount, USB2
Lens	25mm C-mount
Cooling	Built in Fan (water required for the optional beam dump or optional power meter sensor)
UV Light Source	LED array
Software	ModeCheck v5.0
Power Requirements	Input: 100-240 Vac, 50-60Hz, 1.5A Output: 12Vdc, 5.0A, w/power jack, UL listed and CE compliant universal power supply included Camera is powered over the USB port
Dimensions	9.5" x 13" x 6.7" 242mm x 330mm x 171mm Not including handle and cabling or any options
Weight	~8 lbs 3.6kg
Beam Dump (optional)	Water cooled and rated for 5kW total power
Power Meter (optional)	5000W-SH; up to 5kW total power 10kW-SH-V2; up to 10kW total power
Laptop Computer	Provided by user; Vista-32 or Windows 7 is required
Compliance	Unit meets CE and RoHS requirements

The optional rugged case is recommended for safe storage in an industrial facility

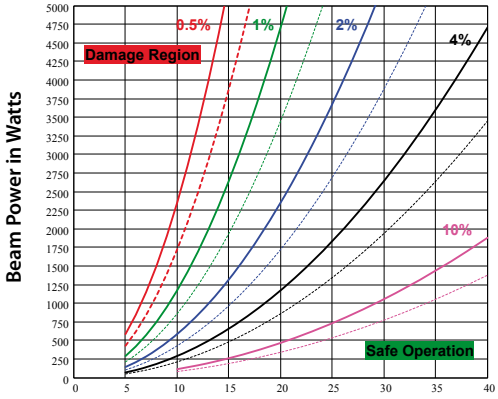
Sampling Wand %



Damage and Saturation Power vs Beam Dia

Safe Operation is to the Right of the Solid line. Image Saturation is approximately the Dashed line. Chose a sampling Wand that contains your beams maximum power and minimum diameter to be near but below the dashed line for safe and best beam viewing.

Sampling Wand %



Damage and Saturation Power vs Beam Dia

Ordering Information

Item	Description	P/N
MODECHECK CO_2-5kW	ModeCheck, CO_2 sampler for 10.6µm beams up to 5kW, beam width up to 30mm; includes 2 user selectable wands from selection below	SP90211
0.5% wand	0.5% beam wand sampler, see damage and saturation chart	SP90324
1% wand	1% beam wand sampler, see damage and saturation chart	SP90325
2% wand	2% beam wand sampler, see damage and saturation chart	SP90326
4% wand	4% beam wand sampler, see damage and saturation chart	SP90327
10% wand	10% beam wand sampler, see damage and saturation chart	SP90283
Beam Dump; 5kW	Beam dump for up to 5kW continuous, includes mounting bracket, requires continuous water flow.	SP90224
5000W-SH	Power sensor, measure CO_2 power up to 5000W; water cooling needed	7Z02119
Mounting Hardware, 5000W detector	Mounting hardware for 5kW power sensor. Required when ordering the 5000W-SH sensor	SP90212
10kW-SH-V2	Power sensor, measure CO_2 power up to 10,000W; water cooling needed	7Z02645
Mounting Hardware, 10,000W detector	Mounting hardware for 10KW power sensor. Required when ordering the 10kW-SH-V2 sensor	SP90213
ModeCheck storage/carrying case	Ruggedized ModeCheck storage/carrying case	SP90227
Collimating 2" Lens Adapter	ModeCheck Lens Adapter (MLA) enables a ModeCheck to recollimate a focused CO2 laser beam. MLA should be ordered with the ModeCheck so that it can be factory installed.	SP90329

3.8.5 High Power - In-Line Industrial Beam Monitoring

3.8.5.1 II-VI-CO_2 Series

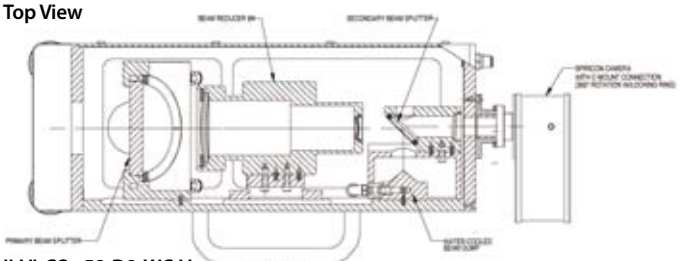
- An in-line industrial laser beam monitoring solution
- Rapidly tune lasers for best performance for each job
- Monitor fluctuations while processing
- Optimize beams in real-time
- Diagnose faults quickly

The II-VI-CO_2-BS-35 Profiler Beam Sampler was developed by II-VI, a leading industrial optics supplier, specifically to enable measurement and viewing of high power industrial CO_2 beams. Spiricon and II-VI have teamed up to provide solutions to vexing laser beam stability, alignment, tuning, and optimizing difficulties.

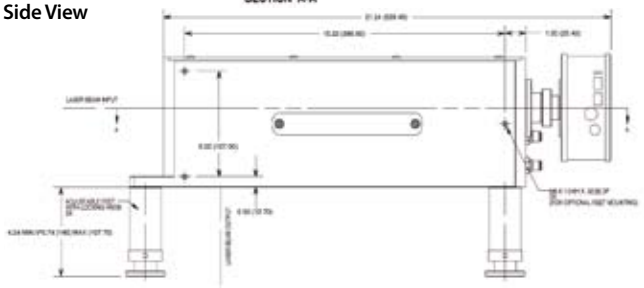
II-VI-CO2-BS-35

The II-VI-CO_2-58 series Profiler consists of a set of turning mirrors that direct the beam to a sampling beam splitter, and then returns it to the original in-line path. After passing through the splitter, the sampled beam passes through additional attenuation and a beam telescope to size the beam for a Pyrocam III infrared camera. The camera is connected to a PC computer through a Firewire interface. A Basic Image Viewer presents 3D isometric plots, 2D color contour plots and grayscale, among other views. Add BGS-PC-PIII beam analyzer software to access many quantitative analysis, computations and charting functions.
The II-VI-CO_2-58 Series Profiler is similar to the BS model but the original beam is not returned "in-line". Both a horizontal and vertical entry model are available.
The Pyrocam III with BGS-PC software must be ordered separately.

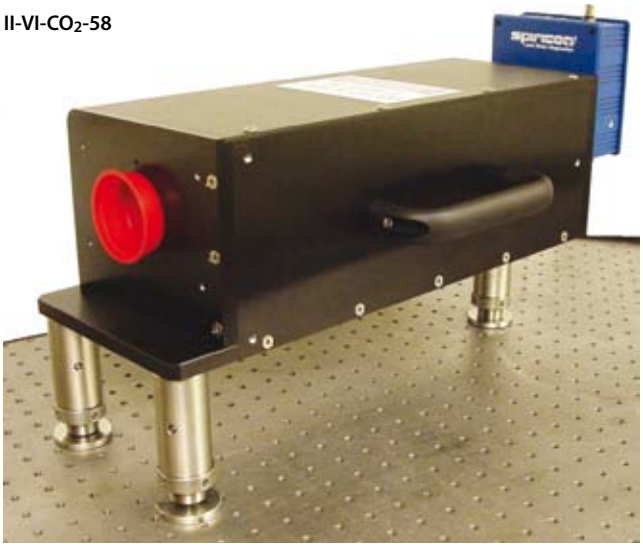
II-VI-CO_2-58-D8-WC-V
Top View



II-VI-CO_2-58-D8-WC-V
Side View



II-VI-CO_2-58



Model	Wavelength	Power	Beam Width	Beam Input	Cooling
II-VI-CO_2-BS-35	10.6µm	up to 8kW	20mm	Vertical or Horizontal	Requires external water
II-VI-CO_2-58-D8-WC-H	10.6µm	up to 10kW	29mm	Horizontal	Requires external water
II-VI-CO_2-58-D8-WC-V	10.6µm	up to 10kW	29mm	Vertical	Requires external water

Ordering Information

Item	Description	P/N
II-VI-CO_2-BS-35	II-VI-CO_2 in-line sampler, for 10.6µm beams up to 8 kW. Beam width up 20 mm. Pyrocam III Beam Profiler System required (ordered separately). Recommended model: PY-III-C-A or PY-III-C-B with a Germanium 10.6µm window. BGS-PC-PIII laser beam analyzer software included with Pyrocam system	SP90062
II-VI-CO_2-58-D8-WC-H	CO_2 laser beam sampler for lasers up to 10kW. Input Clear Aperture is 58mm. Requires cooling water. Horizontal entry. Built-in 8X beam reducer and adapters for Pyrocam III. Order Pyrocam III separately. BGS-PC-PIII laser beam analyzer software included with Pyrocam system	SP90160
II-VI-CO_2-58-D8-WC-V	Same as above but with Vertical Entry	SP90161

3.9 Goniometric Radiometers

LD 8900, LD 8900R Far-Field Profilers

Profiling divergent light sources presents many challenges, but Photon's far-field profilers characterize the angular radiation intensity of light simply and accurately in real time. Both the LD 8900 and LD 8900R (wide dynamic range Goniometric Radiometer) provide full 3-dimensional measurements of the far-field pattern in minutes or less, with far better resolution than a CCD camera. The LD 8900 far-field profiler provides direct real-time far-field measurements with >24dB dynamic range, while the wide dynamic range LD 8900R has a dynamic range of >36dB, which provides greater detail in the "tails" of the far-field pattern. Both models have an angular sampling resolution of 0.055º and a field-of-view of ±72° (144º), and are ideal for characterizing the light flux from many sources, including VCSELs, laser diodes (LDs), optical fibers, optical waveguides, and more. With the LD 8900R, measurement of the mode field diameter of optical fiber is possible in real time with greater than 5% accuracy. The LD 8900 and the LD 8900R are available with either a silicon or InGaAs detector and have a standard entrance aperture of 2mm, with an optional 10mm entrance aperture for use with larger sources such as LEDs and LD bars.

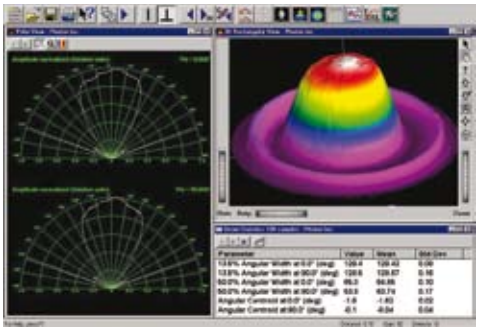
LD 8900 and LD 8900R complete systems include:

- The Scan Unit
- The Motion Control Module
- Goniometric Radiometer Acquisition and Analysis Software for Microsoft Windows operating systems
- PCI Interface Box
- Power and instrument cables
- An optional semi-custom source mount, specifically designed to meet your application needs, can be quoted upon request for either the LD 8900 or the LD 8900R

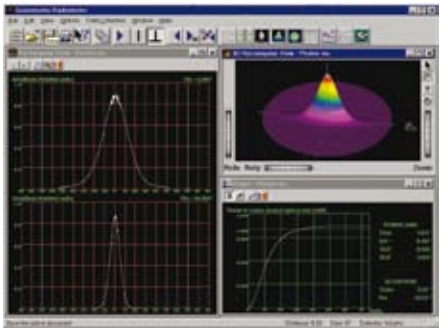
Mode Field Diameter in Real Time with LD 8900R

The LD 8900R allows for real-time measurements of Mode Field Diameter (MFD) with an accuracy of ±5%* for a nominal 10µm single-mode fiber. Mode Field Diameter (MFD) of single-mode optical fiber is measured using the methodology described in the Telecommunication Industry Association/ Electronic Industries Association (TIA/EIA) Standard FOTP-191. Specifically, the MFD is calculated using the Petermann II integral, with data sampled at angular resolution of 0.055° and collected over an angular extent of ±72° (144° viewing angle).

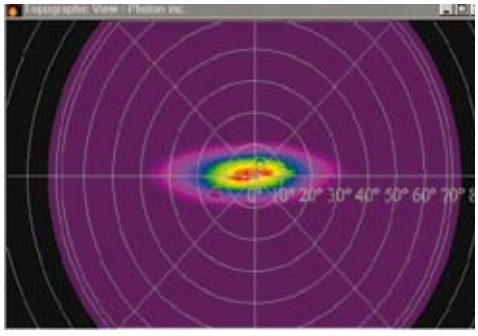
*If greater accuracy is required, Photon's LD 8900HDR is specifically designed to measure MFD and A_{eff} to greater than 0.5%



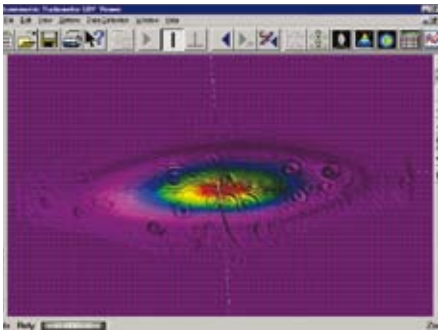
Polar View (left); 3D View (top); Beam Statistics (bottom) with LD 8900R



Windows Showing Unifomity of a Laser Diode



Topographical View - LD 8900R



Laser Diode Diffraction Rings

LD 8900/LD 8900R System Specifications

Sensor/Detector	
Scan Radius	84mm
Pinhole Size	1000µm (options available)
Entrance Aperture	2mm standard (optional 1cm)
Field of View	±72° (144 degrees)
Azimuthal Scans	1, 2, 10, 20, 50, 100, or 200
Spatial Sampling Resolution	0.055 degrees, 3241points/scan
Spectral Range	
Silicon detector	320-1100nm
InGaAs detector	800-1700nm
Optional UV	190-~1100nm
Source Input Power for >400nm	
Mirror Damage Threshold CW	900 W/cm^2
Mirror Damage Threshold Pulsed	1 J/cm^2
LDs, multi-mode fiber w/ NA >0.5	10's of µW to 10's of W*
Single-mode fiber	1µW to 1W**
For wavelengths <400nm	Contact Factory
Higher power options available	Contact Factory
Source Output	CW or Pulsed (rep rates >10kHz)
Parameters Measured	
Angular Widths	FWHM, 5%, 13.5%, 2 user-specified clip levels
Numerical Apertures	FWHM, 5%, 13.5%, 2 user-specified clip levels
Angular Width Ratios	FWHM, 5%, 13.5%, 2 user-specified clip levels
Angular Position	Centroid, Peak
Intensity or Amplitude	Centroid, Peak, 2 user-specified locations
Mode-Field Diameter	LD 8900R only
Relative Integrated Power	Relative Power in user-specified cone angles about an arbitrary axis
Data Update Rates	
Single scan updates:	~ 5Hz
Perpendicular Scan updates	~ 0.5Hz
3D Profile Acquisition Time*	* Times are PC dependent
10 azimuthal scans	~7s
20 azimuthal scans	~14s
50 azimuthal scans	~35s
100 azimuthal scans	~70s
200 azimuthal scans	~140s
File Saving and Data Logging	
	Program Data and Setup Configuration Files
	ASCII file Profiles and Summary Parameters
	Raw 3D Scan Data in binary format
	Screen Captures: BMP, JPG, GIF, TIFF, PNG
	Log to Files and COM Ports
Communications	
	RS-232 Serial COM port required ActiveX Automation
Electrical/Mechanical	
AC Power Required	110V ~ 60Hz standard, 220V ~ 50Hz optional (Installation Category: Class II)
Main supply voltage fluctuations:	Not to exceed ±10% of the nominal voltage; Transient overvoltage according to Installation Category II; Pollution Degree 1 or 2 in accordance with IEC 664.
Dimensions mm	
Scanning Unit	318 × 228 × 241
Scanner	203 × 165 × 165
Motion Controller	51 × 89 × 248
Environmental Conditions	
	Indoor use
Temperature	5°C – 40°C
Altitude	Up to 2000m
Maximum relative humidity	80% for temperature up to 31°C decreasing linearly to 50% relative humidity at 40°C

Ordering Information - Goniometric Radiometer Far-Field Profilers

All Goniometric Radiometer LD 8900 Far-Field Profiler Systems include the Scan Unit, PCI Controller Interface, Current MS Windows software, including ActiveX Automation commands.
All LD 8900R systems include the above as well as a dynamic range >36dB with 0dB source. System incorporates 16-bit digitizer, light scatter control and special amplifiers to achieve higher dynamic range than standard LD8900. For pulsed operation, please consult the factory.

Item	Description	P/N
LD8900/InGaAs	Goniometric Radiometer for characterizing the angular radiation intensity from a laser diode between 800nm and 1700nm wavelength. Entrance aperture 2mm.	PH00173
LD8900/Si	Goniometric Radiometer for characterizing the angular radiation intensity from a laser diode between 320nm and 1100nm wavelength. Entrance aperture 2mm. Full 3D capability. Features dynamic range >36dB with 0 dB source.	PH00174
LD8900R/InGaAs	Wide Dynamic Range Goniometric Radiometer for characterizing the angular radiation irradiance from a fiber optic, wave guide, laser diode, VCSEL, or LED between 800nm and 1700nm wavelength.	PH00175
LD8900R/Si	Wide Dynamic Range Goniometric Radiometer for characterizing the angular radiation irradiance from a fiber optic, waveguide, laser diode, VCSEL or LED between 320nm and 1100nm wavelength. Full 3D capability.	PH00176
Options		
WL-O	Wavelength option	PH00183
Pulsed InGaAs Option	Failsafe operation for pulsed sources operating at repetition rates >10kHz with pulse widths >500ns. For operation below 10kHz, there are possible gain saturation states, dependent on repetition rate, pulse width, and source power. Consult the factory when operating under these conditions for failure mode assessment. When questionable, pulsed source operation should be verified against CW operation.	PH00185
Pulsed InGaAs Upgrade Option	Pulsed Upgrade Option to an existing Goniometric Radiometer InGaAs system. Failsafe operation for pulsed sources operating at repetition rates >10kHz with pulse widths >500ns. For operation below 10kHz, there are possible gain saturation states, dependent on repetition rate, pulse width, and source power. Consult the factory when operating under these conditions for failure mode assessment. When questionable, pulse source operation should be verified against CW operation. Includes software upgrade. Contact Factory for details.	PH00186
PCI Controller Upgrade	Interface to allow use with standard PCI interface of desktop PC. Includes an interface box for 9180 controller card, PCI Interface card and cable, and factory calibration and realignment. System should be returned to Photon for installation. Includes software upgrade.	PH00187
Optional Mount of User Device -LD 8900 Mount	Photon will provide one semi-custom mount of customer's laser diode device. Submit device particulars for specific quote. With this option, the instrument can be used immediately and provides one example test fixture.	PH00181
LD8900 Software Viewer	Goniometric Radiometer Software Viewer for LD8900 models (8-bit). Allows users to open, review and re-analyze files that are saved using any PC computer. The Viewer has all the data processing features of the software. You can read files saved.	PH00181
LD8900R Software Viewer		PH00439
Fiber Mount - /FC	Plate and mount for a single mode fiber with FC connector. Label on plate includes reference distance between source and datum plane.	PH00189
Fiber Mount - /SC	Plate and mount for a single mode fiber with SC connector. Label on plate includes reference distance between source and datum plane.	PH00190
Fiber Mount - /ST	Plate and mount for a single mode fiber with ST connector. Label on plate includes reference distance between source and datum plane.	PH00191
Fiber Mount -/BF	Plate and mount for a single mode fiber without connector. Label on plate includes reference distance between source and datum plane.	PH00192
Option to Fiber Mount /BF - / Ribbon	Optional 4-Fiber Ribbon Cartridge for the Fiber Mount /BF (Bare Fiber). Requires /BF.	PH00193
Extended Cable Option - EXT Cable	Cable lengths extended.	PH00184
NIST Reference Standard	N.A. Reference Standard: traceable to NIST for use with Goniometric Radiometer/Far-Field profilers; i.e. LD8900 and/or LD8900R. Data provided: N.A. and Angular Widths at 50%, 13.5% and 5% clip levels, with standard deviation [with a recorded, exact source to aperture distance]. NIST reference standard includes: LD source Single Mode Test Fiber Required Mounting Plate in a storage case.	PH00188

LD 8900HDR Far-Field Profiler

The photonics community needs a method for very high dynamic range measurements of optical fiber, waveguide and other optical components. Advances in DWDM technology, deployment of standard fibers, and the development of specialty fibers all require more accurate characterization. These high-dynamic-range measurements of irradiant light flux have been very difficult to obtain. Photon has the solution: our Goniometric Radiometer, the LD 8900HDR Far-Field Profiler.

Measurement Parameters

The LD 8900HDR Far-Field Profiler uses goniometric methodology to measure true 3-dimensional profiles of optical components with up to 93 dB dynamic range. All measurements are taken with the emitting fiber, planar waveguide, laser diode or LED inserted directly into the center of the instrument's radial measurement area. For optical fiber, the far-field distribution pattern is acquired without bending the fiber. Bending the fiber can cause analysis and reporting inaccuracies. Parameters measured for optical fiber are:

- Mode Field Diameter (MFD) – used to evaluate losses due to mismatch at connections of fibers and fiber components.
- Effective Area (Aeff) – used to assess non-linear effects
- Numerical Aperture (NA) – a measure of the angular width of the fiber output. NA is equal to the sine of the half angle (sin θ/2) at a specified percentage of the peak value.

The Model LD 8900HDR analysis software calculates these optical fiber parameters from the far-field profile, the method described in the TIA/EIA FOTP-191 standard for MFD requiring a minimum of 50dB for proper measurement. The TIA/EIA FOTP-132 standard for A requires a minimum of 50dB for proper measurements as well.

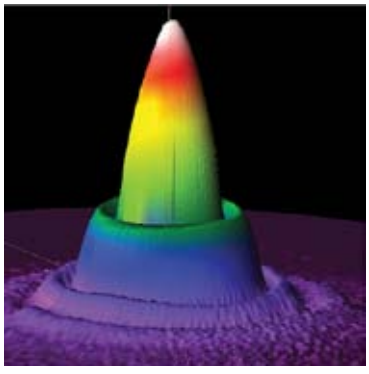
This wider dynamic range provides greater signal-to-noise detail in the tails of the far-field pattern. Real-time data gathering and reporting of sample optical fibers or other sources is valuable for manufacturing and quality assurance evaluation.

Hardware and Computer

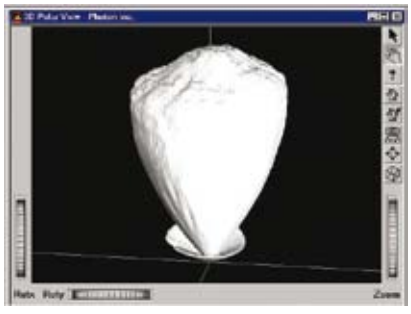
The LD 8900HDR is a modular system that allows either one-dimensional or three-dimensional measurements.
The 3D module is easily exchanged with the 1D hardware, and the system can be purchased with the 1D hardware, the 3D hardware or both. There are specially designed fiber mounting clips available for both the 1D and 3D configurations with a specially modified fiber cleaver and clip that guarantees proper fiber alignment. In addition, custom mounting devices are available for high dynamic range measurements of waveguides, laser diodes and LEDs.

The controller comprises the PC microprocessor, data acquisition card, scan-control card and LD 8900HDR acquisition and analysis software. A reference calibration standard (NIST traceable), 1310nm, 0dBm LD Light Source is also available. This is the measured reference at the time of original manufacture that can be used for unit verification by the user at a later date. For high dynamic range measurements in the visible spectrum, a silicon detector can be substituted with a spectral range of 320-1100nm and even higher 103dB dynamic range. Maximum light source unit size for direct measurements is approximately 12.7mm by 12.7mm.

In the 3D configuration the LD 8900HDR includes the 3D Motion Control Module and is capable of full 3D measurements with up to 200 azimuthal planes through the source.



3D profile of a SMF-28 optical fiber using the LD 8900HDR



3D polar view of LED light emission

LD 8900 HDR

LD 8900HDR Specifications

Specifications	1D Single-Scan Data	3D Multi-Scan Data
Parameters measured	MFD; NA; Aeff	MFD; NA; Aeff; Angular Width; Angular Centroid; Angular Aspect Ratios, Angular Peak Position, Relative Integrated Power, Relative Power in user-specified cone angles (NA), Cone Angles (NA) in user-specified % Relative Power
Accuracy		MFD: ±0.5% (for nominal 9mm diameter fiber) NA: <±1% Aeff: <±1%
Scan range		±90°
Scan radius		13.26(cm); 5.22(in.)
Scan time		<20 seconds
Dynamic range		>93dB InGaAs (103dB Si); input power and distribution dependent; 0 dBm (1mW) minimum for >50dB dynamic range
Spatial sampling resolution		0.055°
Spectral range		InGaAs detector: 800-1700nm / Silicon available (350-800nm)
Software		Windows 2000/XP Professional; ActiveX Automation server capability
Software views	Single scan rectangular profile plot; Fields for operator name, fiber type, date, and user comments	Polar profile plot - single or dual orthogonal scans; Rectangular profile plot - single or dual orthogonal scans 3D Polar view; 3D Rectangular View; 2D Topographic View; Beam parameter statistics; Time statistics charts; Relative angular power distribution; Notes window for appending user comments
Scan unit dimensions		267 H x 305 W x 362 L (mm); 10.5 x 12 x 14.25 (in.)
Scan unit weight		~13.6kg; 30lbs.
Maximum light source unit size for direct measurements		~12.7 × 12.7(mm); 0.5 × 0.5(in.)

Ordering Information

Item	Description	P/N
LD8900 HD	Very high dynamic range Goniometric Radiometer designed to measure Mode Field Diameter (MFD) and Effective Area (Aeff) of single mode fiber.	PH00198
1P	Mount for fiber cartridges Interface plate that mounts to the Scan Unit. Accepts all Photon Fiber Cartridges. The cartridges insert into an opening in the plate and are held in the proper meas.	PH00201
CC	Photon Fiber Clip and Clip Cartridge. The Photon Fiber Clip mounts in a modified Fitel Furukawa Cleaver. The fiber is cleaved and positioned simultaneously. Cartridge inserts into the 1D Cartridge.	PH00202
FFC	Fiber Cleaver for use with the Photon Fiber Clip.	PH00203
REF	Standard reference cartridge Includes a Photon Standard SMF-28 Reference Cartridge and a 1310nm-0dBm LD Light Source.	PH00204
BFC	Bare fiber connector for LD8900HDR Cartridge has a v-groove and clamp for holding fiber. Fiber is positioned manually to a visual reference position. Intended for use with specialty fibers that canno.	PH00205
3D	3-D scan module for HDR Interchangeable accessory adds full 3-dimensional measurement capability with up to 200 cuts through the fiber. Includes a 3D Scan Module and Motion Controller.	PH00206
CFP	Connectorized fiber mount for HDR Adapter plate for mounting connectorized fibers. Standard ST, FC, and SC connectors are held by the ferrule tip. Call for other types.	PH00208
Case	Rugged shipping case for LD8900HDR.	PH00209
MfgSoft	Software interface designed for manufacturing. Simple interface screen shows the high dynamic range 1D profile and reports MFD, Aeff, and NA. Includes fields for time stamps, serial numbers, and notes.	PH00210
1W Mount	1-D waveguide mount Waveguide mount for use with 1D Interface Plate.	PH00215
3W Mount	3-D waveguide mount Waveguide mount for use with 3D Scan Accessory.	PH00216
1CustomFxt	Custom mnt for 1-D vers of HDR/LED Prof Custom designed fixtures for mounting novel sources for 1D scans.	PH00217
LED Profiler	A goniometric profiler designed to rapidly measure true 3-dimensional profiles of LEDs providing a ±130 degree measurement around the source, with 0.05-degree resolution.	PH00199
LED profiler w/3180	Same as above but includes state-of-the- art PC running Microsoft Windows operating system with Photon LED Software installed. Configuration required for international sales.	PH00200
3D(LED)	3-D scan module for LED Profiler.	PH00207
3LED Mount	Standard LED mount for use with packaged LEDs. Price dependent on configuration. (Must be quoted for specific device.)	PH00211
3CustomFxt	Photon can provide custom and semi custom device mounts for LED devices, including TE-cooled vacuum chucks for bare chip testing. Mounts are designed to take advantage of the 260 degree field-of-view available in the LED Profiler. Mounting hardware that is compatible with automated test operations can also be designed and supplied by Photon.	PH00214
UV	Allows the use of the LED Profiler with sources emitting at wavelengths below 380nm.	PH00212
PO	Pulsed Operation for LED Profiler.	PH00213

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